Choosing Your First Telescope

ASTRONOMY®

November 1994 U.S. $3.50
U.K. £1.95
Can. $4.95

Latest Comet Smash Photos

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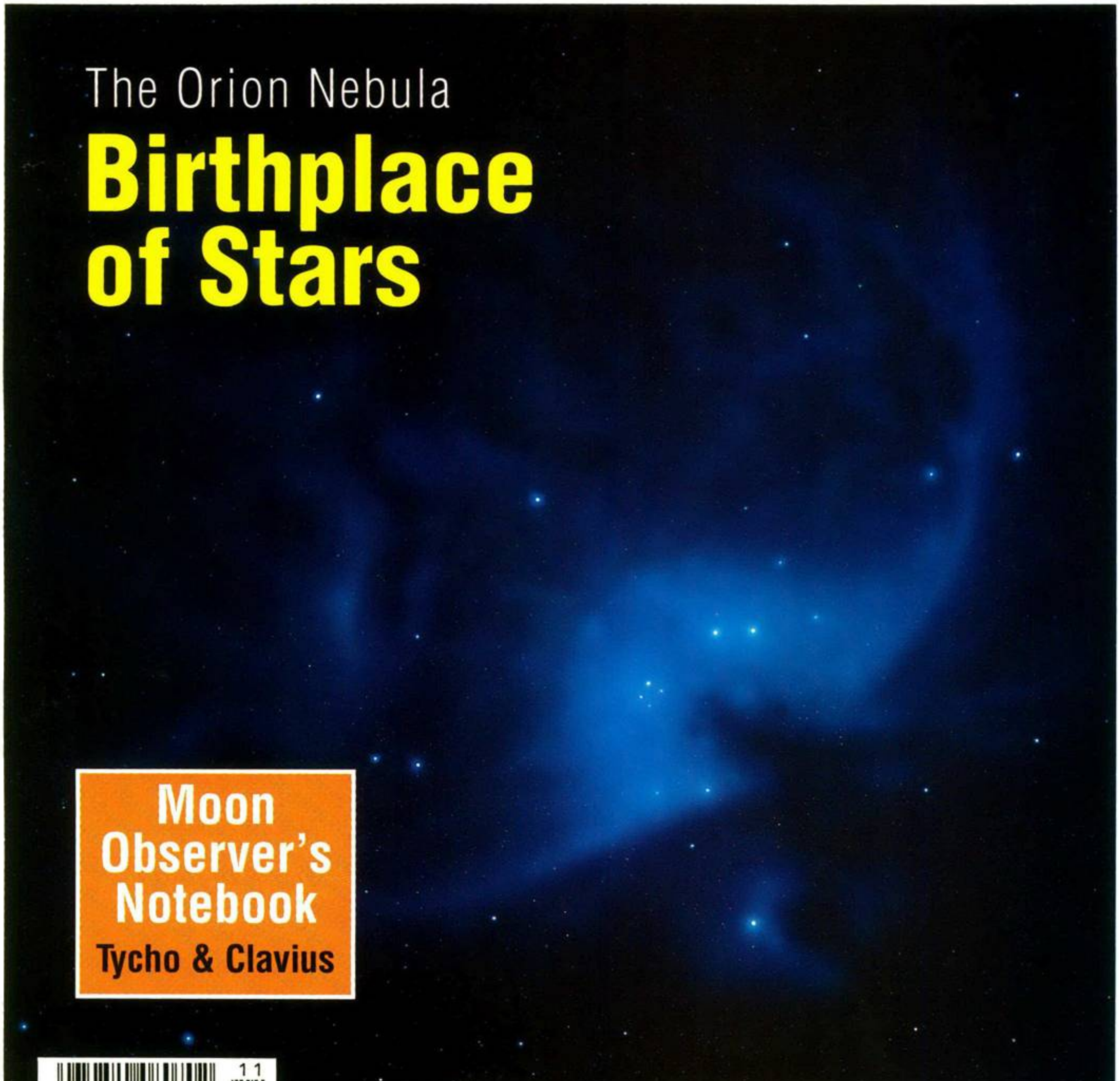

The Orion Nebula

Birthplace of Stars

Moon Observer's Notebook
Tycho & Clavius

- The Best Astronomy Books for Kids
- South American Eclipse Tips

MEADE
12" LX200
10" LX200
8" LX200
MEADE LX200 EMC
Meade

Supplied complete per catalog specifications**:

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**$2895.**
12" LX200 Schmidt-Cassegrain	**$3995.**

Packing & shipping in 48 states: 8"—$105; 10"—$145; 12"—$215.

- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

LX200
SCHMIDT-CASSEGRAINS

Now with *one arc-minute* pointing accuracy and 64,350-object onboard database as *standard-equipment!*

Meade 8", 10", and 12" LX200 models with standard-equipment High-Precision Pointing™ software now automatically GO TO any input RA and Dec, or to any object in the 64,350-object database, to a pointing precision within one arc-minute!

New Meade Version 3.30 software and high-resolution encoders, used in conjunction with the unique Meade SYNC command, now yield the most precise automatic slewing ever offered in a commercial telescope, an observatory-level of precision and *more than 5 times the precision obtainable with any competing computer-controlled telescope.* Data entry through the telescope's keypad hand controller may be made either from the onboard 64,350-object library database *(see description at right)* or by inputting the desired object's RA and Dec.

Such precise object-acquisition, selectable during either altazimuth or equatorial operation of the LX200, has numerous important implications for the serious observer:

HIGH PRECISION
HP
POINTING

LX200's with High-Precision Pointing have the HP logo-plate affixed to the telescope's drive base.

☐ Use the GO TO command to *find and center an object in the field of a 4mm eyepiece.*

☐ With other telescopes, acquiring even bright objects on the chip of a CCD imager is generally a chore at best, searching and slewing by trial-and-error until at last the object is positioned on the chip. The LX200's High-Precision Pointing places *every* object on *every* CCD chip *every* time.

☐ Suppose you wish to CCD-image a supernova in an 18th magnitude galaxy—a galaxy invisible *except* through the process of CCD imaging. With Meade High-Precision Pointing, the galaxy can be placed on the chip of every commercially-available CCD unit.

☐ Photographing or imaging faint objects such as the planet Pluto, or comets and asteroids near the photographic limit of the telescope, and plotting the motion of these objects night-to-night, now becomes practical, since the photograph or image may be taken *without the observer ever having seen the object visually,* but knowing that the LX200 will place the object precisely in the telescopic field.

All Meade LX200 models now include a 64,350-object onboard database as standard equipment.

Imagine having 64,350 celestial objects at the tip of your finger: 64,350 objects that you can actuate and center in the telescopic field just by entering and pressing GO TO on the hand controller. **More than 6 times the size of object libraries included with competing telescopes,** the Meade 64,350-object library includes an incredible array of phenomena—virtually a lifetime of deep-space study, even for the advanced observer:

12,921	galaxies from the Uppsala General Catalog; the complete UGC catalog.
7,840	objects from the New General Catalog; the complete NGC catalog.
5,386	objects from the Index Catalog; the complete IC catalog.
21,815	variable stars; the complete listing from the General Catalog of Variable Stars.
15,928	stars from the Smithsonian Astrophysical Observatory (SAO) catalog of stars brighter than 7th magnitude.
351	alignment stars for the LX200 telescope.
110	Messier objects; the complete listing.
8	major planets from Mercury to Pluto.
64,359	objects, total

SPECIFICATIONS: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel display on the drive base; manual and electric slow-motion controls on both axes; keypad handheld controller with digital readout display, permanently programmable Smart Drive™, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,350-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (for field operation from any 12v. auto cigarette lighter plug, use the Meade #1812 Electronic DC Adapter, a 4-oz. unit available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case; complete operating instructions.

ADVANCED PRODUCTS DIVISION

Meade Instruments Corporation

World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
16542 Millikan Avenue, Irvine, Calif. 92714 ☐ (714) 756-2291
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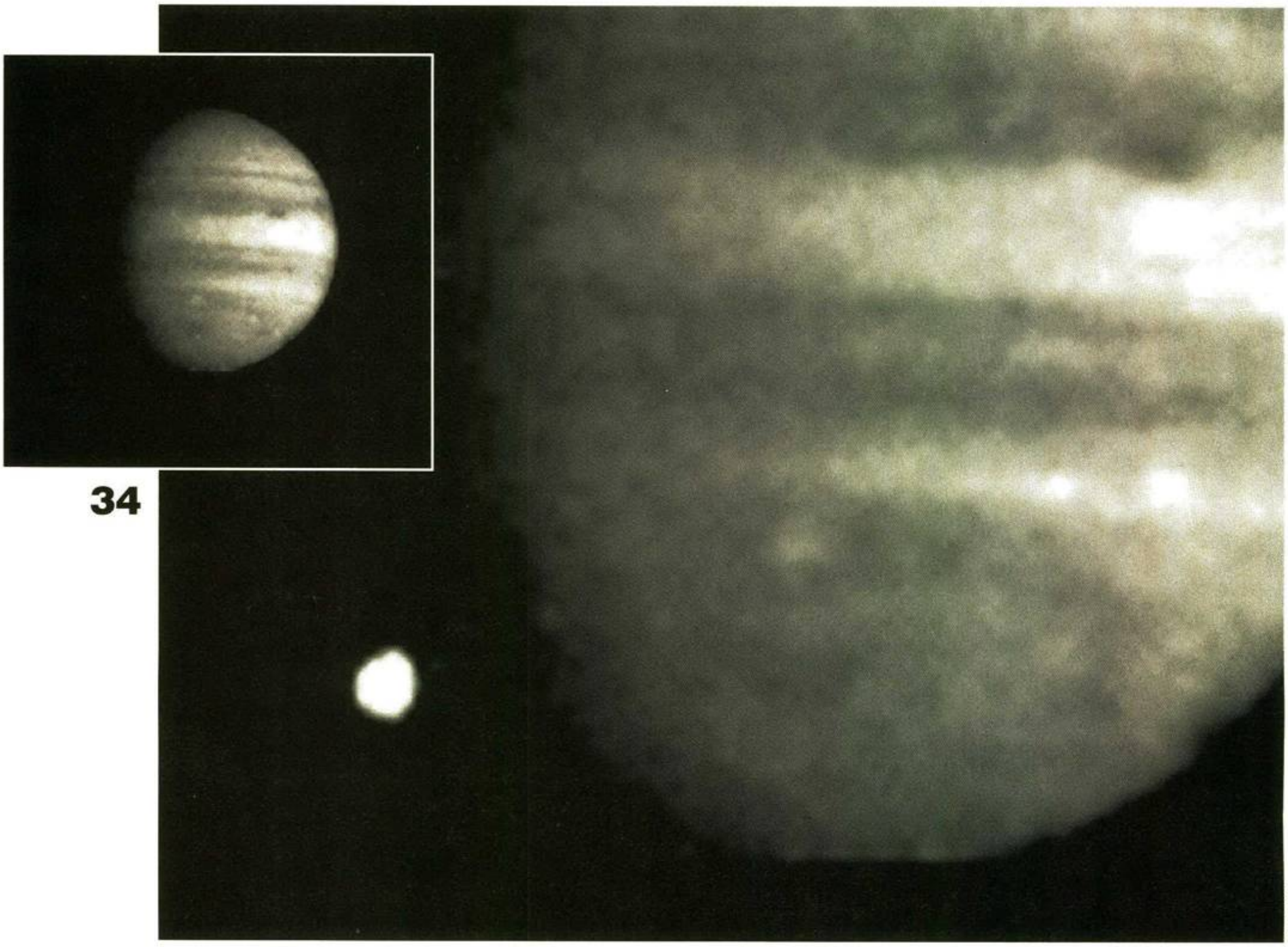
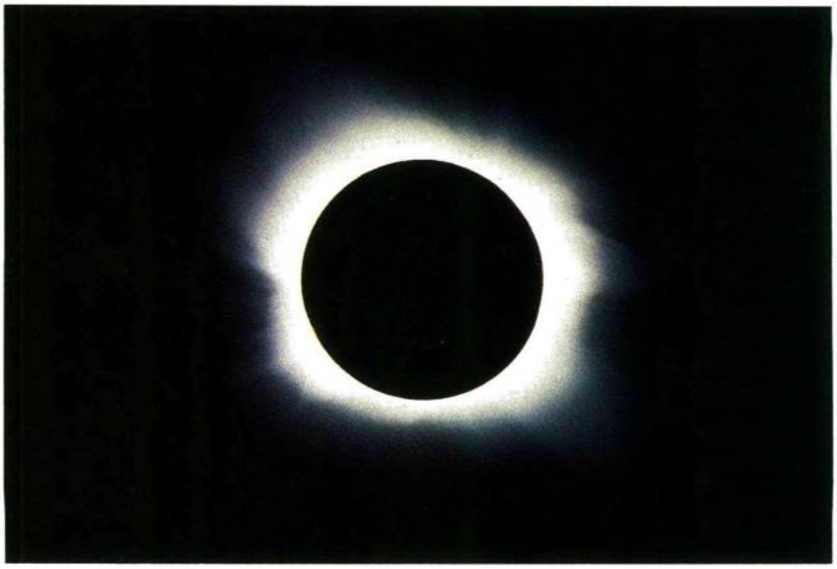


34

NASA/JPL

78



82

Andreas Gada

34

Jupiter's Smash Hit

Contrary to astronomers' predictions, the visible scars left by the Comet Shoemaker-Levy 9 impacts were not material dredged up from Jupiter but debris from the comet itself. By Robert Burnham.

40

The New Stars of M42

By observing the Orion Nebula in radio waves, X rays, and infrared radiation, astronomers are beginning to understand how stars form. By Jean-Pierre Caillault.

46

Telescopes That Fly

To get clear views into the warm hearts of infrared-emitting regions, asstronomers jet to 40,000 feet, above 99.9 percent of Earth's water vapor. By Sally Stephens.

54

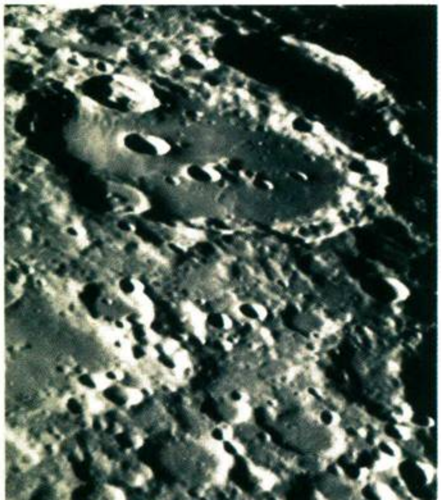
Sky Almanac

Eclipses of the Sun and Moon take center stage this month, but don't overlook Mercury's best morning appearance of the year. By Deborah Byrd and Jeff Kanipe.

64

A Stroll Through Tycho and Clavius

The southern highlands feature the Moon's youngest big crater lying near an ancient, pockmarked one. By Michael T. Kitt



Jean Dragesco

70

T is for Telescope

Buying that first telescope is a huge step into the hobby of backyard astronomy. Here's what you need to know before making that purchase. By John Shibley.

78

Astronomy Books for Kids

Want to feed a child's interest in astronomy? You won't go wrong with one of these outstanding titles. By David Bruning.

82

Reaching for the Corona

Eclipse aficionados will flock to South America this month for up to four minutes of totality. An experienced eclipse chaser gives the lowdown on what to expect and what to take along . By Joel K. Harris.

DEPARTMENTS

6 Behind the Scenes
- The New 1995 *Observer's Guide*

6 Letters

16 Viewpoints
- Totality, Cinema, and Crucifixion

20 AstroNews
- Galaxy Mergers in the Coma Cluster
- Universe Is Old: Galaxies
- Universe Is Young: Supernovae
- Do Hot Planets Betray New Solar Systems?
- Primordial Helium Found
- High Energy Gamma-Ray Burst Detected
- Ulysses Views Sun's South Pole
- Surveyor Sets Sights on Mars

26 Amateur News
- Universe '94 Is a Hit

87 Reader Reports
- Watching the Comet Go Boom

96 New Products
- Park's 16-inch Newtonian-Cassegrain
- Meade CCD Cameras and Autoguiders
- 102mm Refractor from Takahashi
- New Binocular Series from Celestron

102 AstroBytes
- View the Sky with Shareware

106 Astronomy Books
- Seeing Space and Time

116 Meetings and Events

120 Readings and Credits

122 Advertiser Index

COVER

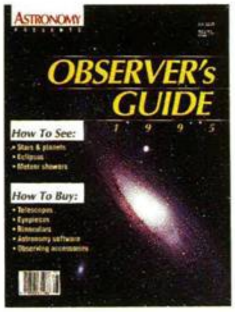
A GLORIOUS SIGHT IN BACKYARD SCOPES, the Orion Nebula (M42) also rates as a prolific site of newborn stars. To learn more about this hotbed of star formation, see page 40. Illustration by Edwin Faughn.

BEHIND THE SCENES

Our New 1995 Observer's Guide

Coming to a newsstand near you on October 25 is the result of a year-long effort from the ASTRONOMY staff: the 1995 *Observer's Guide.* We pulled together all the essential information every backyard astronomer needs each year and put it into one convenient publication.

The *Observer's Guide* opens with a month-by-month reference of sky events in 1995. There you'll find the dates and times for viewing not only planetary conjunctions and oppositions, but also solar and lunar eclipses, meteor showers, asteroids, periodic comets, and the like. It'll help you plan your observations for the coming year — you'll want to keep it handy all year long.



ASTRONOMY: Chris Becker

Next comes a big feature on telescopes, eyepieces, binoculars, and observing accessories. It contains complete and up-to-date listings of all the makes and models on the market. Telescopes are grouped by type and aperture, and we have highlighted all their important features so you can compare one with another. The same goes for eyepieces, binoculars, and many other accessories.

But the equipment section does much more than just list makes and models. It is also a richly informative guide that will help anyone, whether new to astronomy or long experienced, make a wiser purchase. For those bewildered by all the technical terms and data — not to mention all the choices — the text will walk them painlessly through buying a telescope and outfitting it with accessories.

Then there's software. We last surveyed this field in the May issue — only six months ago — but already significant changes have occurred. New programs are on the market, CD-ROM products continue to pour out, and image processing is expanding rapidly. This is the hottest field in all of backyard astronomy, so we've updated the software survey to reflect the new developments.

The last feature in the *Guide* is a kind of Yellow Pages of astronomy. Listing planetariums, museums, observatories, astronomy clubs, and star parties, it's a take-it-with-you directory of "space places" where you can make exploring astronomy an enriching experience for yourself and the rest of the family.

I want to end on one last, important note. The 1995 *Observer's Guide* is a new publication; I invite you to visit a newsstand and buy a copy (or order one from ASTRONOMY by calling 800-533-6644). Since the *Observer's Guide* aims to help you enjoy astronomy more, I would also appreciate hearing what you think of it and what you'd like to see in future issues.

Sincerely,

Robert Burnham

Robert Burnham
Editor

LETTERS

CCDs, Yes! CCDs, No!

Randall Wehler's comments about the profusion of CCDs and related high-tech gadgets ("Imagining vs. CCD Imaging," August 1994), suggest a multitude of possibilities. Why do so many people feel threatened by emergent technologies? For more than 20 years I've owned an 8-inch SCT. I've dabbled in astrophotography, spending what I could afford to, and within a few years I may purchase a CCD setup. I also have an Astroscan, which I use to show my students planets and bright deep-sky objects.

Does doing astrophotography mean I'll be retiring my eyes? Of course not. These things are just tools designed to assist or complement, not replace the eye. And there will always be nights when I eschew such devices and simply wander out under the darkness with only an atlas and a heavy coat. If you enjoy what you do, why begrudge others the opportunity to see their interests reflected in your favorite magazine? — *Matthew Leissring, Woodland, California*

I agree with Mr. Wehler 100 percent. I too am getting bored with all the CCD hype. My idea of "high-tech" is dropping some Tech Pan into its developer and admiring the results. I would never trade a photographic image for one of those pixel-grainy images.

Sure, it's tempting to buy into the CCD experience, especially in places like New Jersey where on a summer night the bright planets can be hard to find. I find a certain satisfaction in using my eye-brain combination, however, not substituting technology for my mind.

I would rather alternately freeze and fight off mosquitoes than play astronomy on a computer, inside and away from the natural beauty of the universe. — *Ben Funk, Jr., North Brunswick, New Jersey*

As I browse the pages of ASTRONOMY each month I can't help but marvel at the

(continued on page 14)

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U.S. and International Newsstand Distribution
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Canadian Newsstand Distribution
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ASTRONOMY is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Editorial phone: (414) 796-8776; advertising: (800) 558-1544; customer service: (800) 446-5489; subscriptions: (800) 533-6644 7 days a week, 24 hours a day; fax (414) 796-0126.

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Second-class postage paid at Waukesha, WI, and additional mailing offices. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription price: 1 year $27. Canadian and foreign: 1 year $38, GST (#R122713209) included; please remit in U.S. funds. Not responsible for unsolicited materials. POSTMASTER: Send address changes to Astronomy, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Canadian second-class postal permit no. 545775. Printed in the U.S.A.

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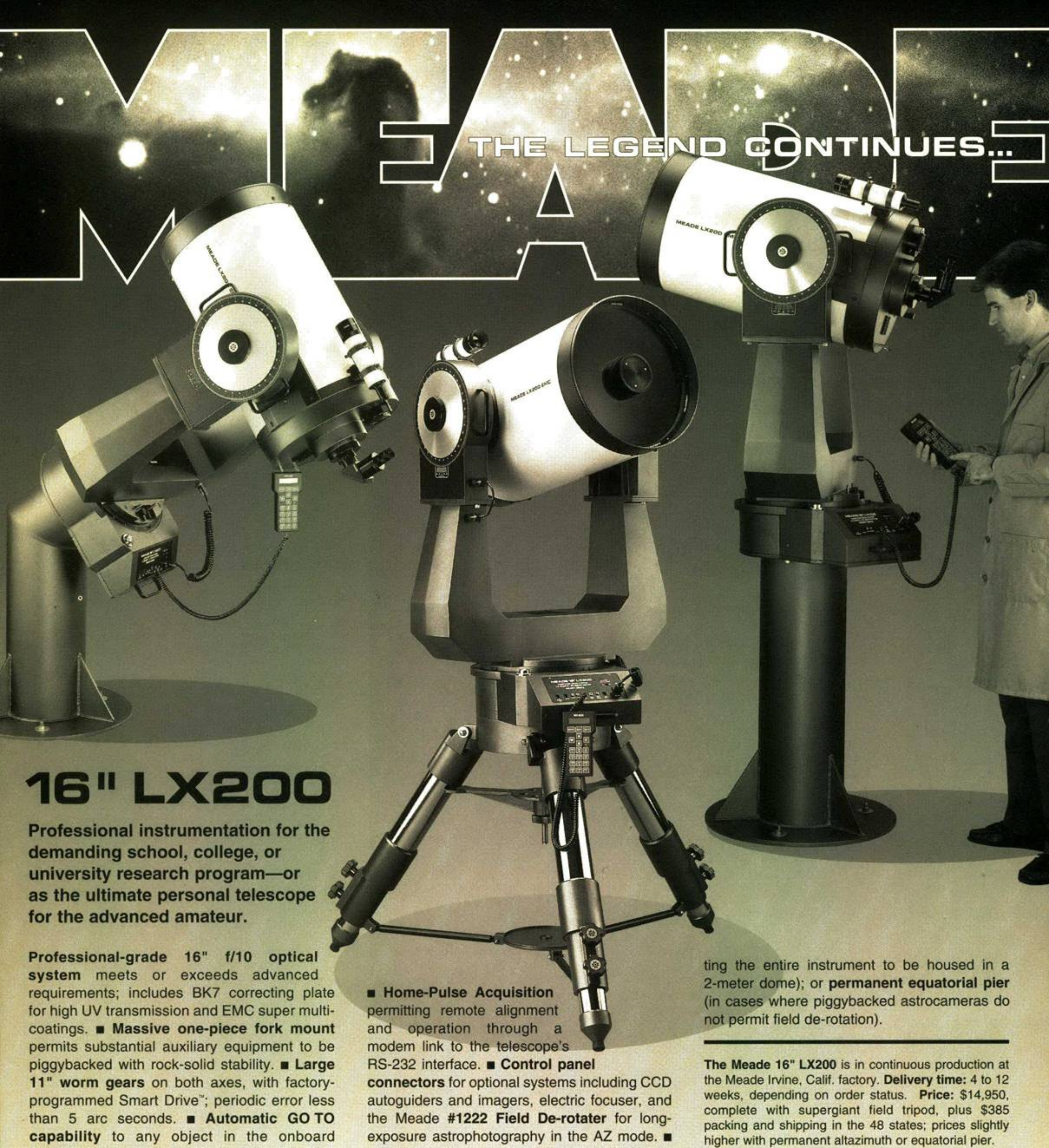

16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 optical system meets or exceeds advanced requirements; includes BK7 correcting plate for high UV transmission and EMC super multi-coatings. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,350-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates,** from photo-guide to fast-slew on both axes, simultaneously. ■ **Micro-processor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks, depending on order status. **Price:** $14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states; prices slightly higher with permanent altazimuth or equatorial pier.

For your copy of the all-new **1994-95 Meade General Catalog** ($3.00), write Meade Instruments or contact your authorized Meade Advanced Products Dealer.

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World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur

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STARFINDER™ DOBSONIANS

Now you can buy a Dobsonian telescope with quality Meade® optics and components—at a fraction of the price you'd expect to pay.

And, extended through December 31, 1994, receive a $125 Accessory Package for only $29.95!

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STARFINDER
MEADE

10" f/4.5
$565.

12.5" f/4.8
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$395.

Shown with optional #637 6 x 30mm or #545 8 x 50mm Viewfinders

6" f/8
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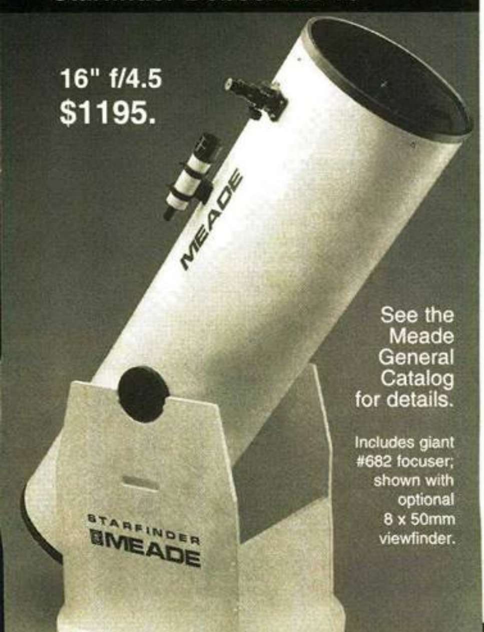
SPECIAL ACCESSORY OFFER!

Through December 31, 1994, at the time you order any Starfinder 6", 8" 10", 12.5", or 16" Dobsonian Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces *and* the Meade #637 6 x 30mm coated achromatic viewfinder for a *total* of only $29.95! Purchased separately, the 2 additional eyepieces and viewfinder sell for $125.85!** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces, with #637 6 x 30mm viewfinder.)*

Starfinder Dobsonian 16



16" f/4.5
$1195.

See the Meade General Catalog for details.

Includes giant #682 focuser; shown with optional 8 x 50mm viewfinder.

Compare Meade Starfinders *feature-for-feature* with other similarly priced Dobsonians!

- **Primary and Secondary Mirrors of Low-Expansion Pyrex® glass!** Unlike the plate-glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians include the *exact same* professional-quality Grade-A, fine-annealed Pyrex® optical systems used on Meade Starfinder Equatorial Reflectors. Optics that meet the theoretical limits of resolution for their apertures.
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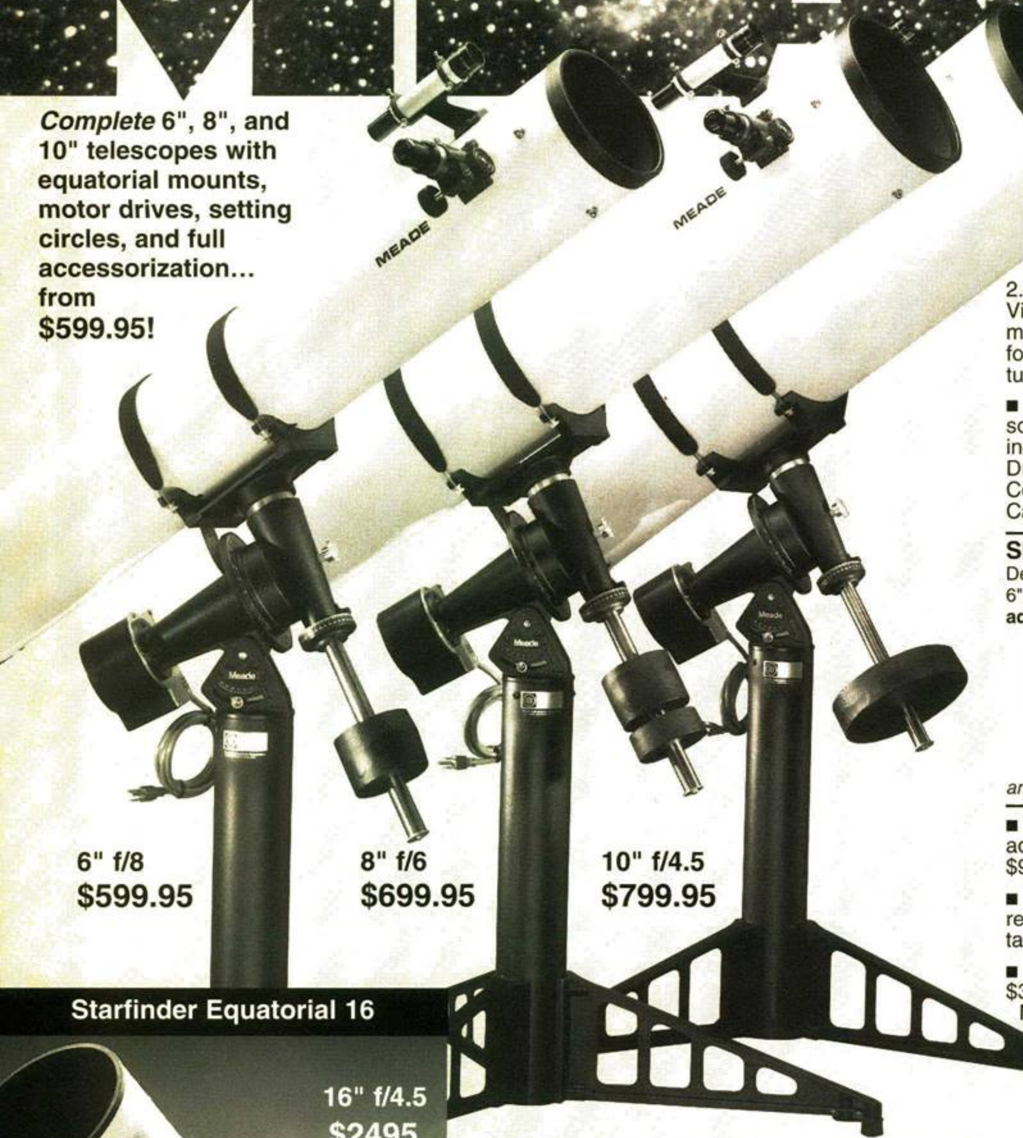
- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(facing page).* All telescopes include a multi-coated MA25mm eyepiece as standard equipment. Each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.
- **Performance!** A Meade Starfinder Dobsonian or Equatorial Telescope opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects–nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space astrophotography.
- **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. 16"–$45 packing, shipped truck freight collect.
- **To Order:** Contact one of the authorized mail-order dealers on the facing page.

MEADE

STARFINDER™ EQUATORIALS

***Complete* 6", 8", and 10" telescopes with equatorial mounts, motor drives, setting circles, and full accessorization… from $599.95!**



6" f/8
$599.95

8" f/6
$699.95

10" f/4.5
$799.95

■ **Electric Motor Drive** (115v/60Hz) with 6 ft power cord: permits **fully automatic** tracking of celestial objects; plugs into any standard outlet.

■ **Standard Accessories and Components:** Precision Rack-and-Pinion Focuser (1.25") with full 2.6" travel; coated achromatic #637 6 x 30mm Viewfinder with crosshair eyepiece and 7° field; multi-coated MA25mm (1.25") eyepiece, threaded for filters; strong, durable, spiral-wound optical tube with attractive white finish.

■ **Optional Accessories:** See the Meade accessories ad in this issue. Additional systems, including #55 Manual Declination Control, #43 Drive Corrector, and #47M Dual-Axis Drive Corrector, are described in the Meade General Catalog.

SPECIAL ACCESSORY OFFER! Through December 31, 1994, at the time you order any Starfinder 6", 8", 10", or 16" Equatorial Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces for a *total* of only $19.95! Purchased separately, the two additional eyepieces sell for $75.90.** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces.)*

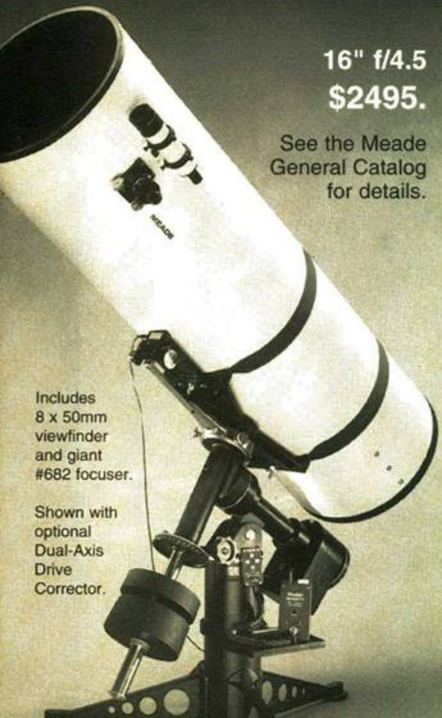
■ **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$65; 8"–$75; 10"–$90. 16"–$55 packing, shipped truck freight collect.

■ All prices shown are suggested USA mail-order retail prices, not including any applicable sales taxes.

■ **All-new 1994-95 Meade General Catalog**–$3.00 postpaid–is available from any authorized Meade dealer or directly from Meade Instruments.

■ For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

Starfinder Equatorial 16



16" f/4.5
$2495.

See the Meade General Catalog for details.

Includes 8 x 50mm viewfinder and giant #682 focuser.

Shown with optional Dual-Axis Drive Corrector.

Standard equipment on 6", 8", and 10" models includes:

■ **Superb Optical System:** Includes hand-figured parabolic primary mirror that meets the theoretical limit of resolution for its aperture, with matching elliptical flat secondary mirror. Both mirrors multi-coated and made of low-expansion, Grade A, fine-annealed Pyrex® glass.

■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs, for rock-solid support of the optical tube. The telescope moves effortlessly from object-to-object on precision bearing surfaces. Polar and declination shafts are 1" solid steel. Setting circles on both axes facilitate the location of faint objects directly from their catalogued coordinates.

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Orders: 800-843-4780; Info.: 818-505-8424.

CITY CAMERA, Dearborn, MI.
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FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
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EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types for 1994, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.29)

32mm (52°); **40mm** (44°) each: **109.95** (3.79)

56mm (52°; 2") **229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine *wide-field views of star fields and nebulae. In astro*photography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

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Series 4000 Super Plössl 56mm Eyepiece (2"): Buy one eyepiece at the regular price of $229.95 and receive the #929 2" Diagonal Mirror FREE.

Series 3000 Plössl 40mm Eyepiece (1.25"): Regular $79.95; Sale Price $69.95. Save 12%.

All prices plus shipping, as noted in product descriptions. This offer is valid between June 20 and October 31, 1994, at participating Meade dealers and is subject to product *availability.*

Series 4000™ Super Wide Angle

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

Series 4000™ Ultra Wide Angle

The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–***4.7mm:* $179.95** (3.29); ***6.7mm:* 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Series 4000™ #140 2x Apochromatic Barlow Lens

The most advanced Barlow Lens available for commercial *telescopes; includes 3-ele*ment, air-spaced optics, multi-coated. Unmatched in image resolution, contrast and color correction. Accepts 1.25" eyepieces. Lens dia. 28mm; clear aperture 26mm.

$79.95 (3.29)

Series 3000™ Plössls

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$57.95** (3.45) **Any 2: $52.95** each; **Any 3: $48.95** each; **Any 4 or 5: $46.95** each.

Series 3000™ Plössl 40mm

A perfect complement to the *Series 3000 Plössls at left*, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

Series 4000 Photo-Visual Color Filters (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

	each **$14.95**	(2.29)
Moon Filter #ND96–Reduces brightness by 87%.	**16.95**	(2.29)
Set #1–4 filters: #12, #23A, #58, #80A	**54.95**	(2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**54.95**	(2.98)
Set #3–4 filters: #8, #21, #38A, #56	**54.95**	(2.98)
Sets #1 & #2–8 filters	**99.95**	(3.45)
Sets #1, #2, & #3–12 filters	**144.95**	(3.79)

#911B
#910B
#908B
#911N
#910N
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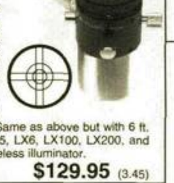
Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters *in heavily light-polluted areas or for extremely* high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95**	(2.98)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95**	(3.29)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95**	(3.29)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95**	(2.98)
#910N–*Threads into 2" eyepieces, 44mm dia.*	**129.95**	(3.29)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95**	(3.29)

World's Most Advanced Illuminated Reticle Eyepiece



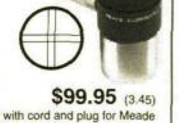
Series 4000 Plössl 9mm, with *rubber* eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

MA 12mm Illuminated Reticle Eyepiece



*Excellent 3-element optical sys*tem, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

MA 12mm—Same as above but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **$99.95** (3.79)

Camera Adapters (1.25" & .965")

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95 (2.98) **1.25": $29.95** (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

Tele-Extenders

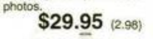
TELE-EXTENDER

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to any eyepiece-holder. Use with T-mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos.

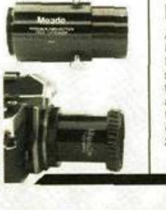
$29.95 (2.98)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece.



$39.95 (2.98)

T-Adapters for SCT's



For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of *all types. 27mm dia. (26mm clear aperture).* Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25"

$59.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

Modified Achromatic Eyepieces

An improvement on the traditional Kellner design, these 3-element Modified Achromatic eyepieces give sharp, faithful, well-corrected images of the moon, planets, and deep-space at an economical price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (2.98)

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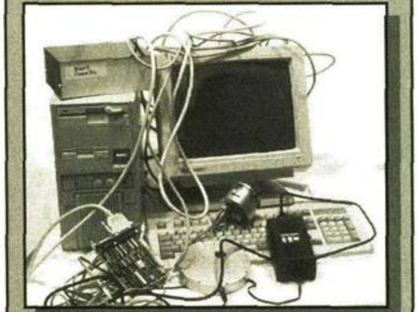

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CIRCLE NO. 21 ON THE READER SERVICE CARD

apparent obstacles faced by the average newcomer to astronomy. The telescope market has a dizzying array of gadgets and accessories. It appears at first glance that one needs to spend at least $1,000 even for a casual entrance into the field. The problem is worsened by the fact that many backyard astronomers who have been around for a while belong to a club and tend to speak their own "in group" language, alienating potential members.

It's not necessary to follow that path, however. I've been a serious backyard observer for about three years. I bought an 8-inch f/4.5 reflector for $500, including some eyepieces and star charts. Large amounts of cash are not necessary to enjoy this hobby, only a quiet night under the stars with a scope or a pair of binoculars. Those who follow this path may find themselves observing even before their high-tech friends have set up. — *Bruce Sahli, Lexington, Kentucky*

> **"I would rather freeze and fight off mosquitoes than play astronomy on a computer."**
>
> *Ben Funk, Jr.*
> *North Brunswick, NJ*

Lowell Observatory's Century of Discovery

Bruce Bond's excellent article "100 Years on Mars Hill" (June 1994) brought back fond memories of reading about Percival Lowell's hypotheses. In addition to the many discoveries Bond's article enumerated, Clyde Tombaugh discovered a comet in 1931. He never reported it, and as communication was not like it is today, other observatories were not asked to confirm it. Unfortunately it will not be recorded as Comet Tombaugh, but thanks to David Levy's painstaking work of uncovering the story of this comet, another fine contribution to astronomy by Mr. Tombaugh has received recognition. — *Robert Alan Soltis, La Jolla, California*

NASA, Please Find Yourself

I missed the Moon shots of the late 1960s and early 1970s. That's because I was born in 1966. However, I did stay glued to the television for the Apollo-Soyuz, Skylab, Viking, Voyager, and first shuttle missions. These later missions were taken for granted. We lost our awe for what NASA was doing, and with this the politicians easily scaled back NASA's budget. Today even the "routine" mapping missions are threatened.

I was born too late to feel the power of Apollo firsthand. Maybe my son, now two years old, will someday be able to feel such power when once again we direct our energies toward the stars. — *Juris Breikss, Highlands Ranch, Colorado*

Sh-h-h-h-h-h

"No Guns 'N Roses" at star parties? (See "A Stormy Perseid Forecast," August 1994.) How about *no* noise? For me, nothing detracts more from the majesty of the heavens than the idiotic sounds of civilization. I doubt that I am alone. Efforts to discourage light pollution are rendered pathetic by the failure to recognize the extent to which noise pollution poisons our lives. — *Robert G. Huenemann, La Honda, California*

A Turn-On?

Hello! I live in a small village outside Mattoon, Illinois. In April a group of my friends ordered solar eclipse glasses, and we watched the ring of sunlight on May 10. In fact, we got special permission from our teachers to watch it. The viewers were Colin St. Michael, R. J. Podeschi, Pat Pelham, Kim Abell, Tony Miller, Katie McMinn, Katie Woodell, Jeremy Coffman, Jamie Wagner, and me.

We're planning to form an astronomy club at our school. In his "Viewpoints" article, Jim Marsh said that kids are being turned off to astronomy (May 1994). All it takes to turn us on, however, is a good celestial event. — *John ZuHone, age 13, Mattoon, Illinois*

See Pluto from Your Backyard

What a great concept, putting the detailed Pluto charts in the May 1994 issue! It's absolutely amazing that I was able to find an object that small and distant from my backyard in the Connecticut skyglow. But I did, with an 8-inch SCT, and I followed the little planet night after night.

Keep challenging us neophyte starhoppers. — *Bob Crelin, Branford, Connecticut*

Correction

In "A Cosmos Close Enough to Touch" (Amateur News, August 1994), the names of Oil City High School students Melody Spence and Heather Tartara were inadvertently scrambled. Our apologies to Melody and Heather. ☐

Send your letters and comments to ASTRONOMY *Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet use 72000.2704@CompuServe.com. Letters may be edited for length and clarity.*

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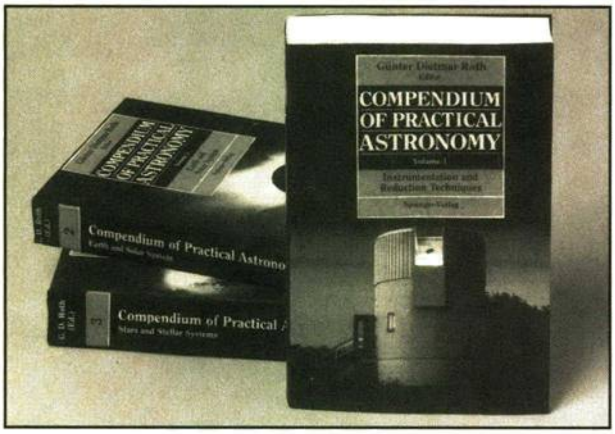

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VIEWPOINTS

Totality, Cinema, and Crucifixion

by Joel K. Harris

As eclipse chasers head off to South America to witness the November 3 total solar eclipse, many will be planning to snap still photographs. Others will seek to capture the eclipse on videotape. But throughout history, very few have attempted to make a movie during an eclipse.

That's not to imply that eclipses haven't been used in movies before. The dramatic possibilities inherent in day's turning to night have drawn producers and directors to eclipses for over half a century. From the 1940 animated classic *Fantasia* and the 1949 *A Connecticut Yankee* in *King Arthur's Court* to such recent motion pictures as *Mermaids, Ladyhawke, Dragonslayer,* and *Superman IV — The Quest for Peace,* eclipses have played key roles in movies.

But in only one instance in the history of feature films has a producer used the genuine article — an actual solar eclipse — as part of the scene being filmed. The producer who made this challenging and daring choice was none other than Dino De Laurentiis, a filmmaker who built his career by remaining faithful to the concept that you don't mimic action in a movie scene for convenience's sake — you go for broke and capture the real thing.

The movie was the biblical epic, *Barrabas,* released in October 1962 by Columbia Pictures. It starred the now legendary actors Anthony Quinn, Ernest Borgnine, Arthur Kennedy, and Jack Palance.

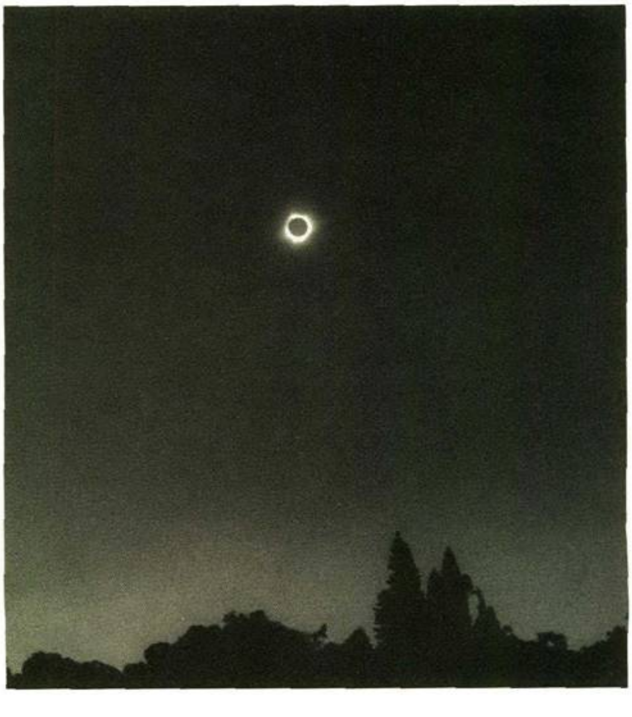
The eclipse filmed was the event of February 15, 1961, in which the Moon's shadow swept across southern Europe, the Black Sea, and Russia. The extraordinary effort of De Laurentiis to use an actual total solar eclipse in the movie gained the picture the unofficial subtitle: "The film that stopped the Sun."

The story is about a ne'er-do-well thief, assassin, and womanizing drunkard, Barrabas. Convicted of a crime and condemned to die, Barrabas escapes his sentence of crucifixion when the crowd selects Jesus Christ instead to endure that tortuous form of execution in his place. With Barrabas' life spared, the rest of the film follows his life as a slave forced to work in the sulfur mines in Sicily and as a gladiator in Rome, all the while concentrating on the torment brought about by surviving unjustly in Christ's stead and his eventual conversion to Christianity.

The decision to film a real eclipse for the crucifixion scene was made by producer De Laurentiis, director Richard Fleischer, and production designer Mario Chiari just 48 hours before the eclipse. To quote De Laurentiis from an article appearing in the *New York Times* on October 7, 1962:

> *Mr. Fleischer and Mr. Chiari conceived the idea that if they could film the crucifixion sequence against the eclipse they would be duplicating the lighting that must have happened on that fateful day nearly 2000 years ago, 'when darkness fell upon the whole land,' and also get something uniquely dramatic and moving on film. I decided to take the gamble and sent a cast and crew of 80 to the village of Roccastrada, 120 miles northwest of Rome, where we*

K. Edwards and M. Vito



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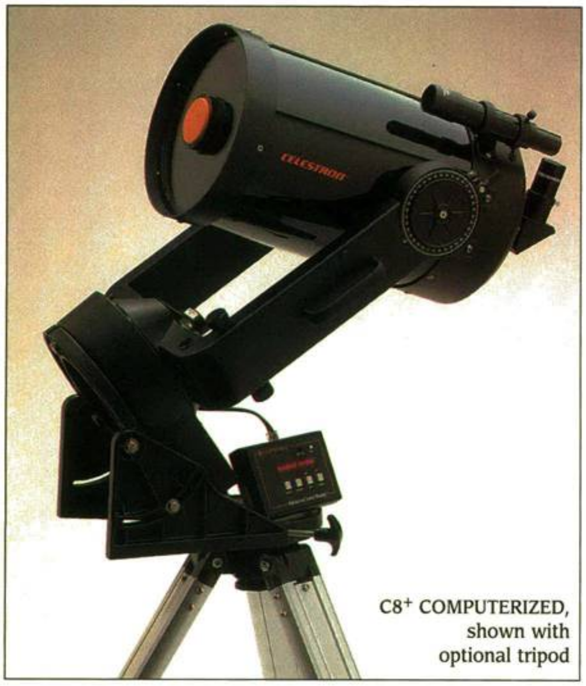
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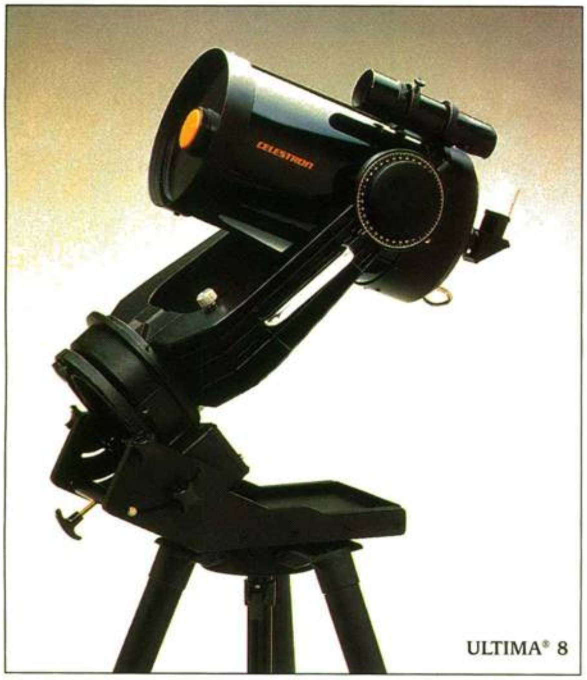
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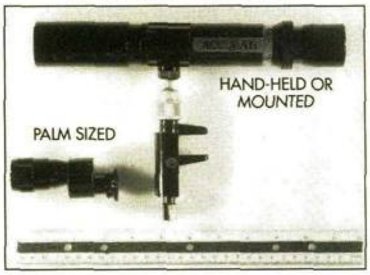

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filmed the crucifixion against the total eclipse of the Sun.

A gamble it was indeed. First, no one to anybody's knowledge had ever attempted to make a movie during totality, let alone tried to photograph actors playing out a scene against the backdrop of such a spectacle. Second, with no historical or technical information to go by, the film's Director of Photography, Aldo Tonti, was literally working in the dark as far as proper shutter settings, exposure times, image scale, foreground lighting, and the like to use for the shot.

On top of all that, working with actors meant working with fallible human beings. What if someone got ill or flubbed a line of dialogue during the shot? As any eclipse chaser knows too well, you can't shout "cut" and then reshoot the scene in such a situation.

A press release from Columbia Pictures talked about the challenge Tonti faced in shooting the eclipse scene:

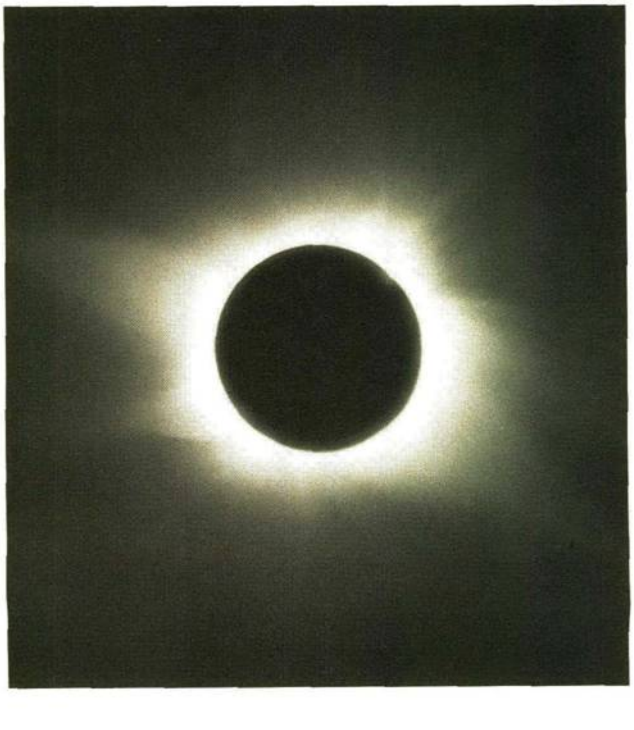
When Tonti was first consulted, he felt that it was too great a risk and that the lighting could probably be achieved better by special effects that could be controlled. But the producer [De Laurentiis] insisted on taking this risk. One camera, with a telescopic lens, was used to photograph the eclipse itself, a second to shoot a closeup of the cross on which the Christ figure hung, and the third for a master shot of all three crosses and the eclipse.

"It was now 7:30 in the morning," says Tonti, "and I had already placed cameras and lamps in position. [According to computer simulations of this eclipse, the Sun was then 91 percent eclipsed, at an altitude of 10.8° above the eastern horizon, and six minutes remained before the start of totality.] But I found it impossible to measure the intensity of the lamps, as the Sun was shining directly into the cameras and I could not even make a guess as to what would happen at the moment of total eclipse.

"I became worried," admits Tonti. "The eclipse was just beginning and we had two minutes of changing light to darkness. My trouble was that there was no precedent in motion picture photography for this kind of shooting and lighting. I was unhappy with the master camera placement. The blinding Sun was causing optical refractions, which created extensive halos, fogging the entire picture."

This ran through Tonti's mind in a matter of seconds and he turned to Fleischer [the director] and informed him he was going to move the master camera. The director was helpless and simply had to depend on the cameraman.

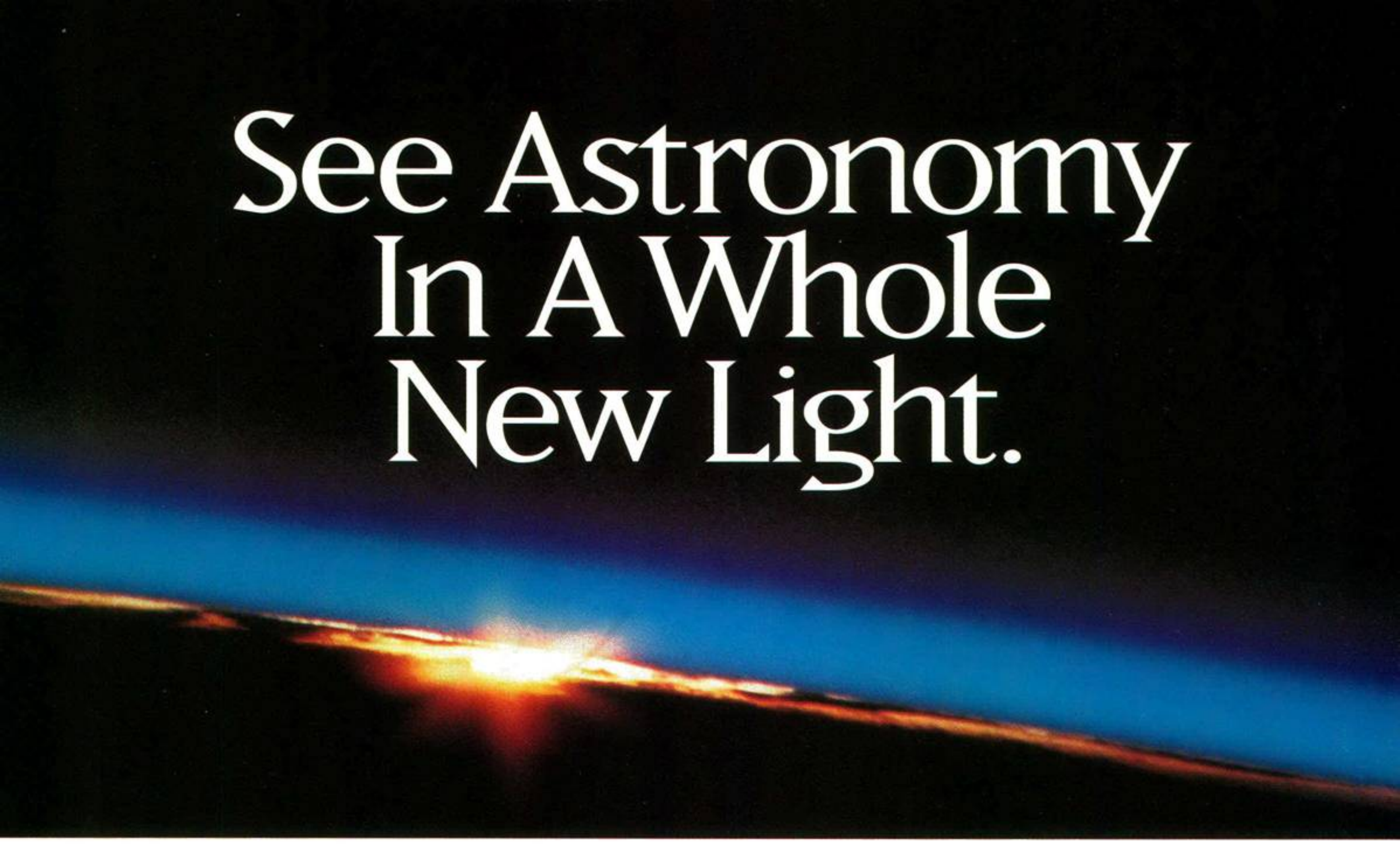
"This is where instinct paid off," continued Tonti. "I moved the camera so that the Sun shone directly into the very center of the lens. This immediately eliminated reflections. But then the heavy filters, I realized, would greatly diminish the intensity of the image. I ripped off the filters, opened up the lens to stop f/4.0, and hoped."



Don Walton

The cameraman admits that he was witnessing "something stupendous and unique, and that if my techniques were correct, I would have photographed the most beautiful scene in my 30 years as a cameraman."

The final result was certainly impressive, as anyone who has seen *Barrabas* and the scene just described can tell you. Considering Tonti had no prior data to go on, his results represented a milestone in the efforts of photographers to capture the beauty of totality on film. ☐



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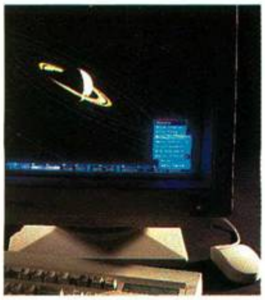

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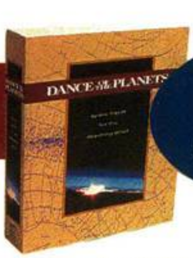

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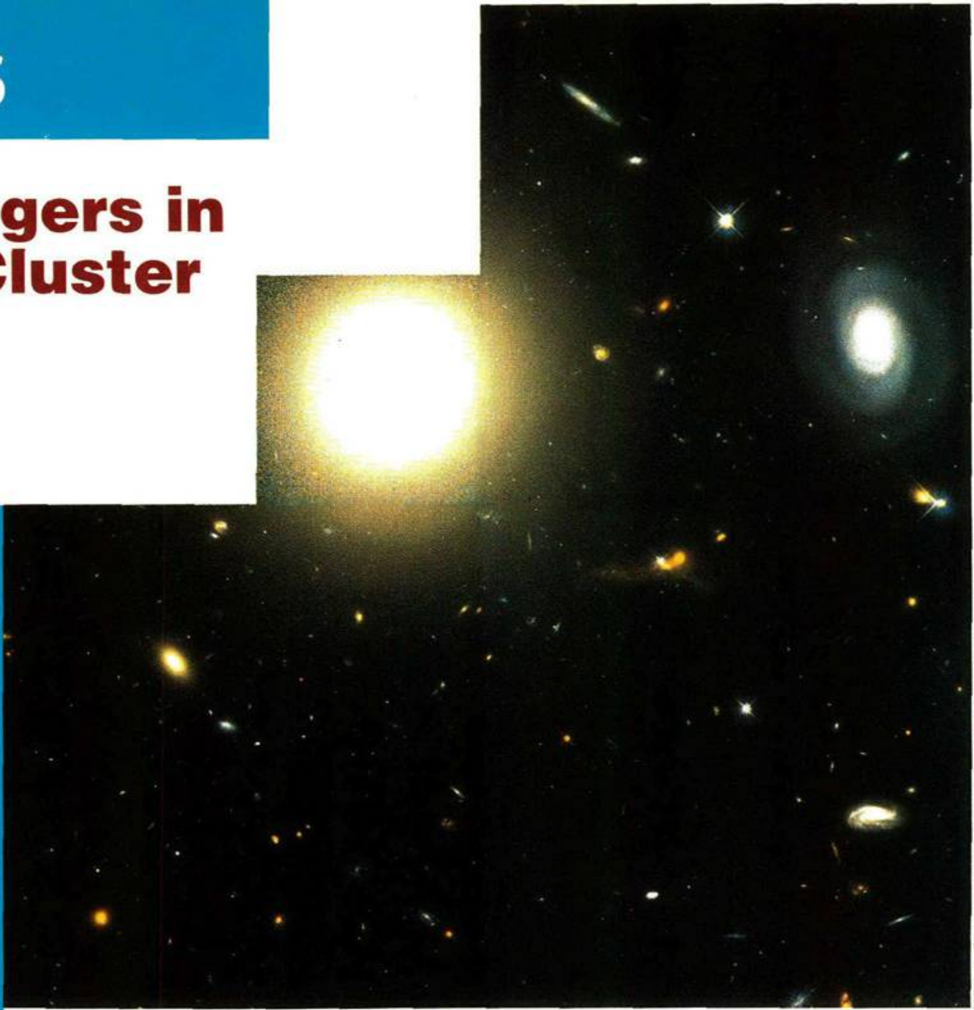
Galaxy Mergers in the Coma Cluster

Astronomers struggling to decide between estimates of the distance between Earth and the Coma Cluster of galaxies accidentally uncovered another interesting fact: The elliptical galaxy NGC 4881, which is in the Coma Cluster, has fewer globular clusters than expected. Galaxies in the densely packed Coma Cluster have undergone numerous encounters and mergers, undoubtedly affecting the formation and eventual fate of globulars in the galaxies.

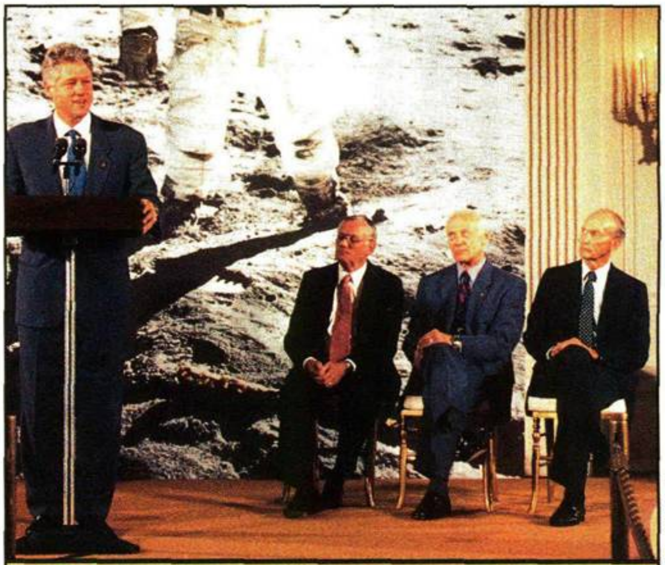
The team of astronomers, led by William Baum of the University of Washington in Seattle, will have to wait to answer the distance question until they can obtain exposures longer than the one taken of the galaxy in March 1994 by the Wide Field and Planetary Camera (WF/PC II) on the repaired Hubble Space Telescope. The new exposures will enable the group to find the brightness at which globulars are most numerous, the so-called turnover magnitude. In the Milky Way Galaxy, the absolute magnitude at the turnover is –7.3. Comparing the apparent turnover magnitude for the globulars in NGC 4881 with the absolute turnover magnitude for globulars in the Milky Way Galaxy provides the distance to the galaxy. The distance determined in this way is important because it doesn't depend on other, possibly inaccurate, distance indicators.

Another team of astronomers has found evidence for mergers in the Coma Cluster. Jack Burns of New Mexico State University in Las Cruces and his group have modeled the motions of galaxies in the cluster as they explain in the June 1 *Astrophysical Journal Letters*. They found that a group of galaxies containing the elliptical NGC 4839 fell into the cluster's center about two billion years ago. The ensuing collisions destroyed most of the group; however a small number of the galaxies in the group passed through the cluster. But the gravity of the cluster is strong enough that in another one to two billion years, the remaining members of the group will fall back into the cluster and get swallowed up just as the other members did.



William Baum (U. of Washington) and the HST WFPC team/NASA

TOO FEW GLOBULAR CLUSTERS was the verdict of astronomers when they viewed NGC 4881 (top center), an elliptical galaxy in the northern portion of the Coma Cluster of galaxies. They created this false-color image from green-light and infrared images taken with the Hubble Space Telescope's Wide Field and Planetary Camera.



The White House

TWENTY-FIVE YEARS TO THE DAY, astronauts Neil Armstrong, Buzz Aldrin, and Michael Collins joined President Clinton in the East Room of the White House for a commemoration of the July 20, 1969 lunar landing of Apollo 11. The President reaffirmed his backing of international space station Alpha as the cornerstone of America's manned space effort. In the audience were the Vice President, members of Congress, other Apollo astronauts, and astronauts from Europe, Japan, Canada, and Russia.

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M1 Crab Nebula. *This expanding gas cloud is the brightest known supernova remnant in the sky. At an estimated distance of 6300 light years it is expanding at 600 miles per second, or some 50 million miles per day, which is one of the highest velocities known in the Galaxy. At the center of this nebula is a remarkably tiny neutron star, probably not more than a few miles in diameter, and with an extremely strong magnetic field, rotating at the astonishing rate of 30 times per second. Sixteen minute ST-5 CCD image taken through a Celestron Ultima 8 at f/6.3 and guided off-axis. Courtesy Jim Riffle, Astro Works West, Arizona.*

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Universe Is Old: Galaxies

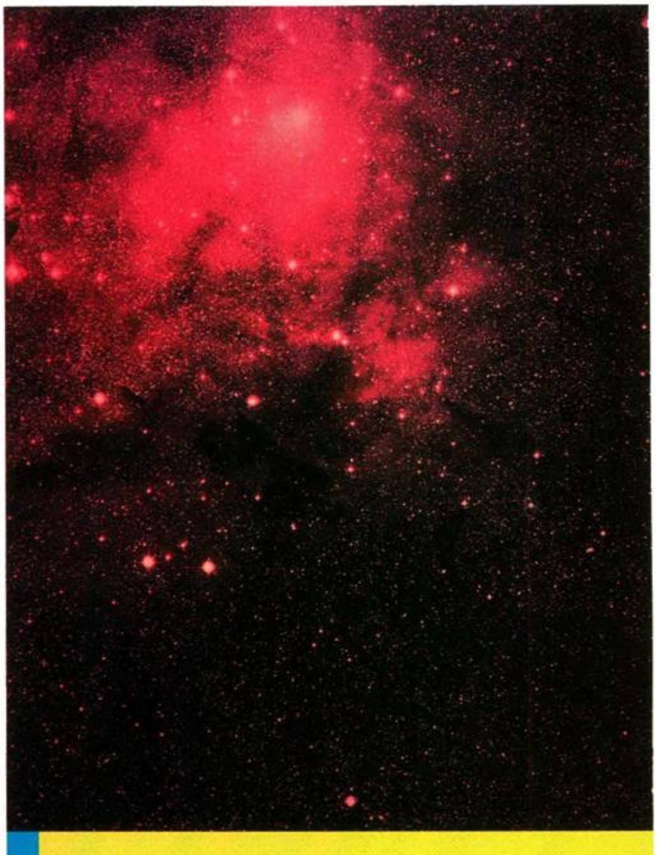
Esther Hu and Susan Ridgway of the University of Hawaii started out looking at red galaxies near distant quasars, hoping to study bursts of star formation. Instead, they may have found two evolved elliptical galaxies at distances that imply the universe may be at least 19 billion years old (assuming a Hubble constant of 15 kilometers per second per million light-years).

Hu and Ridgway used the University of Hawaii's 2.2-meter telescope and the Canada-France-Hawaii Telescope, both located on Mauna Kea, to look in the region of the quasar called PC 1643+4631A. This quasar lies about 18 billion light-years away in the constellation Hercules. The expansion of the universe causes lines in the quasar's spectrum to shift to the red such that their wavelength is 3.79 times their original wavelength. Nearby, the astronomers found two galaxies at a redshift of 2.4, which corresponds to a distance of 16 billion light-years.

As reported in the April 1994 *Astronomical Journal*, these galaxies are redder (as measured in two infrared bands) than any other galaxy yet observed. The researchers infer that they are evolved elliptical galaxies, which indicates that galaxies formed several billion years earlier at a look-back time corresponding to a redshift of 6 (about a billion years after the Big Bang).

E. Hu and S. Ridgway, Univ. of Hawaii

LOOKING BACK 16 BILLION YEARS, astronomers found two ultrared galaxies, which implies that the universe may be at least 19 billion years old. The two galaxies (top left and lower right) appear red in this false-color image created from one blue and two infrared images.



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SPECTACULAR WIDE-FIELD IMAGES are being produced by the second Palomar Observatory Sky Survey (POSS-II), being conducted by astronomers at the California Institute of Technology and the European Southern Observatory. The survey will push the limiting magnitude far deeper than the original Sky Survey of the 1950s, still used as the essential photographic atlas of the sky. The new survey will serve as an improved standard map of the sky against which other photographs can be compared. This enhanced picture of the central portion of IC 1396 in Cepheus was created at the European Southern Observatory from a POSS-II survey plate made with the 48-inch Oshin Schmidt telescope at Palomar Observatory.

Universe is Young: Supernovae

Distance indicators have presented conflicting estimates of the size and age of the universe. (See "Candles that Light the Night," September 1994.) Type Ia supernovae, which occur when white dwarfs explode after accumulating mass from their binary companions, have long served as distance indicators. But now, using a technique that doesn't depend on other indicators to calibrate the scale, astronomers are also finding distances from type II supernovae, stars that explode as they near the end of their lives.

Brian Schmidt of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, and a team of 17 researchers developed the expanding photosphere method to find the distance to a type II supernova. Measuring the brightness of the expanding layers of gas ejected by the stellar explosion, they can estimate the temperature and angular size of the gas cloud. Spectroscopic measurements determine the velocity of the outrushing gas. The angular size and the speed of expansion together yield the distance to the supernova.

In the case of supernova 1992am, located in an unnamed spiral galaxy in the constellation Cetus, the team reported in the April 1994 *Astronomical Journal* that it lies 590 million light-years away. Given the redshift of lines in the galaxy's spectrum, the scientists conclude that the expansion rate of the universe, called the Hubble constant, is 25 kilometers per second per million light-years. This value indicates that the universe is young, perhaps only 10 billion years old, and supports the results of other standard candle methods.

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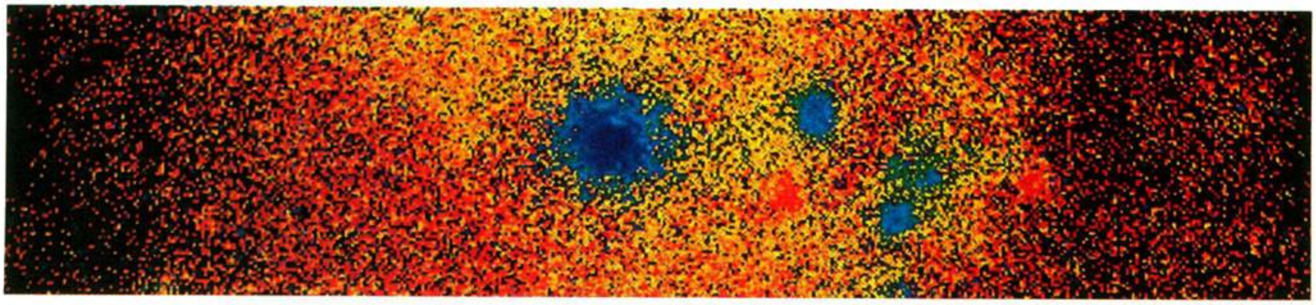

Large Magellanic Cloud - X-ray photograph taken by ROSAT; courtesy by Prof. Dr. J. Trümper, Garching

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Primordial Helium Found

Big bang theory predicts it, now astronomers have finally found it: helium in the early universe. A team of European astronomers using the Faint Object Camera on the Hubble Space Telescope gleaned the evidence in the ultraviolet spectrum of a quasar, according to a paper published in the July 7, 1994 issue of *Nature*. Light from the quasar, located in Cetus, has been traveling to Earth for some 13 billion years, or 90% the age of the universe.

Analyzing absorption features in objects of this type permits astronomers to survey the universe's content out to the distance of quasars. Previous studies have revealed that tenuous clouds of hydrogen gas left over from the Big Bang pepper intergalactic space. After the creation of hydrogen, big big theory says that helium was formed from hydrogen in the first minute or so of the universe's life.

The primordial hydrogen clouds make it tough to find helium's telltale signature in quasar ultraviolet spectra. UV light from quasars is extremely faint and for the most part overwhelmed by UV light given off by the clouds. To overcome this handicap, the astronomers used HST to find a quasar that was bright enough to have its UV spectrum analyzed.

"Although we've almost certainly detected helium, we cannot directly tell how much of the absorption is caused by [primordial helium] clouds and how much by the intergalactic medium, based on the FOC data alone," cautions team member Peter Jakobsen of the European Space Agency's Astrophysics Division. That will have to wait for the resolution of an improved spectrograph, scheduled to be installed on the next Hubble servicing mission later this decade.

Do Hot Planets Betray New Solar Systems?

A new way to search for other solar systems relies on the fact that making a planet is a slam-bang business. Alan Stern of the Southwest Research Institute in San Antonio, Texas, proposes looking for newborn planets that belong to other stars using the heat of giant impacts during their formation.

"The direct detection of light from planets about another star has never been accomplished," says Stern. "Planets like those in our solar system today aren't luminous enough to easily reveal themselves at interstellar distances against the billion-times brighter light of their parent star.

"So," Stern suggests in an autumn issue of the *Astronomical Journal*, "instead of looking for mature planets when they are just reflecting light, why not look at young planets in the late stages of their accretion? That's when giant impacts will turn their surfaces molten and temporarily make them much more luminous at infrared wavelengths."

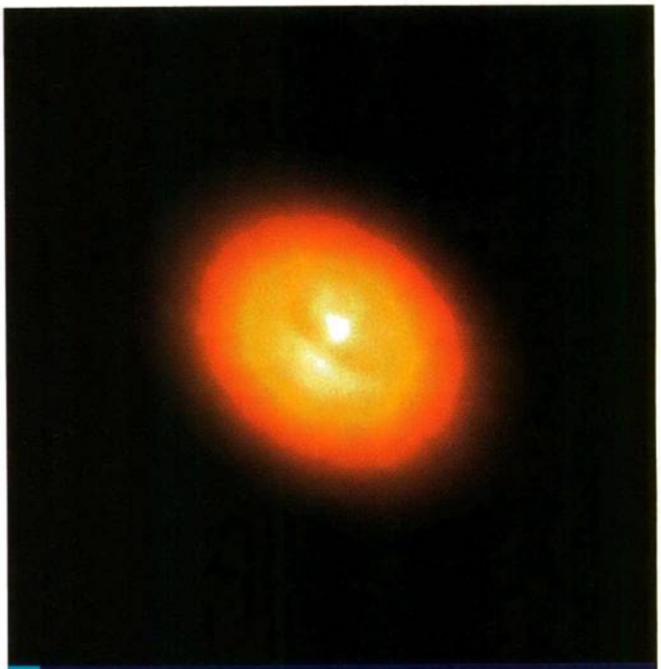
His calculations show that from about 450 light-years away (the average distance of the nearest young star-forming regions), a terrestrial-sized planet that has recently suffered a giant impact is far more detectable in the infrared than today's mature (and cool) Earth is. Theoretical work shows a young terrestrial planet would have a surface temperature of 1,500 to 2,500 kelvins and would remain hot for roughly a thousand years. Stern estimates that if terrestrial-type planets are *commonplace*, about 1 percent of the nearby young stars should possess a hot planet detectable by the world's largest telescopes.

Giant planets — Jupiters and Saturns — would be even more conspicuous provided they also suffered a giant impact. (The large axial tilts of Saturn, Uranus, and Neptune are thought to come from gigantic impacts late in these planets' formation.)

Stern estimates that two Keck-class telescopes (each 10 meters in aperture) working as an interferometer pair could survey about 250 stars over five to seven years and find any young terrestrial-type planets these stars contain. The project would need only about 10 percent of the telescopes' observing time. He also points out that a single Keck telescope could detect a newborn Uranus in about one hour, if it looked at the right star.

High Energy Gamma-Ray Burst Detected

The Compton Gamma Ray Observatory and the Ulysses spacecraft have detected a burst of radiation lasting 100 times longer and having an energy over ten times greater than anything observed in the past. The observations of the February 17, 1994 event further confound attempts to explain the energetic gamma-ray bursts, one of the greatest mysteries of modern astrophysics (see "A Burst of Gamma Rays," October 1991, and "Bursting with Surprises," March 1992).



Werner W. Zeilinger, Institut für Astronomie der Universität Wien

THE CORES OF ELLIPTICAL GALAXIES may hold clues to whether or not they contain central black holes. The 10th-magnitude elliptical NGC 4261 in the Virgo Cluster, for example, shows a bright core, rings of dust, and a bright gas shell surrounding its nucleus in this new image. Astronomer Werner W. Zeilinger of the Institut für Astronomie der Universität Wien in Austria and his colleagues created the photo by combining a Hubble Space Telescope picture and an image taken with the 3.5-meter New Technology Telescope in La Silla, Chile. The result is by far the best view of NGC 4261's central region to date, which should help astronomers determine the motions of the gas and dust surrounding the galaxy's center. Ultrafast motion of gas and dust would suggest the presence of a central black hole.

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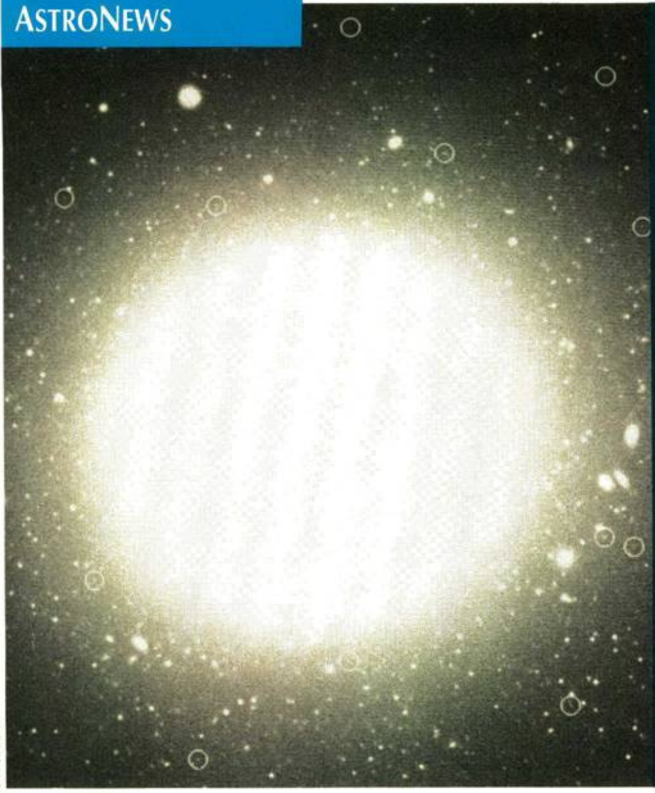

A CLOUD OF PLANETARY NEBULAE (circled) surrounds the giant elliptical galaxy NGC 1399 in Fornax. Magda Arnaboldi and Ken Freeman of the Mount Stromlo Observatory measured the velocities of these planetaries and found the mass of the galaxy must be ten times greater than previously suspected from the galaxy's visible light and the supposed amount of surrounding dark matter. Because the planetaries are orbiting the galaxy so rapidly they would escape were it not for a vast unseen halo of dark matter that must surround the galaxy. The finding is another strong confirmation of the existence of large quantities of dark matter in galaxies.

CTIO/ESO

Similar though less energetic gamma-ray bursts lasting from a fraction of a second to a little over a minute reach Earth about once a day. February's event would have just added to that growing list except it shattered two records. According to Kevin Hurley of the Space Sciences Laboratory at the University of California at Berkeley, who announced the result at the June meeting of the American Astronomical Society, this latest burst continued for well over an hour. Even more surprising, the energy of the gamma rays is 12 times anything seen in the past, some 25 billion electron volts. (This compares to about 50,000 electron volts for a typical dental X ray.)

Although many theories have been proposed to explain gamma-ray bursts, virtually none had predicted such a long-lived, high-energy event. Some astronomers think this latest burst supports the idea that stars colliding in distant galaxies cause these violent explosions, but the jury is still out — and likely will remain out for the foreseeable future.

Ulysses Views Sun's South Pole

After four years in flight, including a spin past Jupiter in 1992, the Ulysses spacecraft finally passed under the Sun in June 1994. The spacecraft, a joint project of NASA and the European Space Agency, then spent four months exploring the Sun's southern polar region. "For a long time we have suspected that much of the solar phenomena studied at and near Earth was controlled by conditions in the Sun's polar regions," says ESA scientist Richard Marsden. "But never before have we been able to observe those processes."

Using Ulysses, Jack Gosling of the Los Alamos National Laboratory near

(continued on page 30)

AMATEUR NEWS

Universe 94 is a Hit

ASTRONOMY: Dave Bruning

NEW ASTRONOMY PRODUCTS DISPLAYED at UNIVERSE 94 attracted the attention of more than a thousand visitors to the expo, sponsored by The Astronomical Society of the Pacific and ASTRONOMY.

More than a thousand astronomers flocked to Northern Arizona University in Flagstaff, Arizona, at the end of June for the week-long 106th annual meeting of the Astronomical Society of the Pacific. UNIVERSE 94, cosponsored by ASTRONOMY magazine, started the festivities. The two-day expo featured numerous talks on current research by Clark Chapman, David Malin, Gene Shoemaker, and Alan Stern. Amateur astronomer Jack Newton showed the latest in color imaging using CCDs, ASTRONOMY's Dave Eicher talked about deep-sky observing, astronaut Claude Nicollier described what it was like to fix the Hubble Space Telescope, and David Levy presented a timely talk on the then-imminent crash of Comet Shoemaker-Levy 9 into Jupiter.

The weekend also included an exhibition by over 50 companies displaying the latest in telescopes and accessories. The star party held Saturday night at the Northern Arizona University campus observatory had about 200 visitors looking through more than a dozen different telescopes. On Sunday and Monday, 175 teachers from across the country and Guam gathered for a workshop called "The Universe in the Classroom." Professional astronomers took over for the rest of the week with their series of technical symposia on the contents of the solar system, robotic telescopes, and the history of astronomy.

College Park, Maryland, will be the site of UNIVERSE 95 on Saturday and Sunday, June 24 and 25. Make plans to join in the fun next year.

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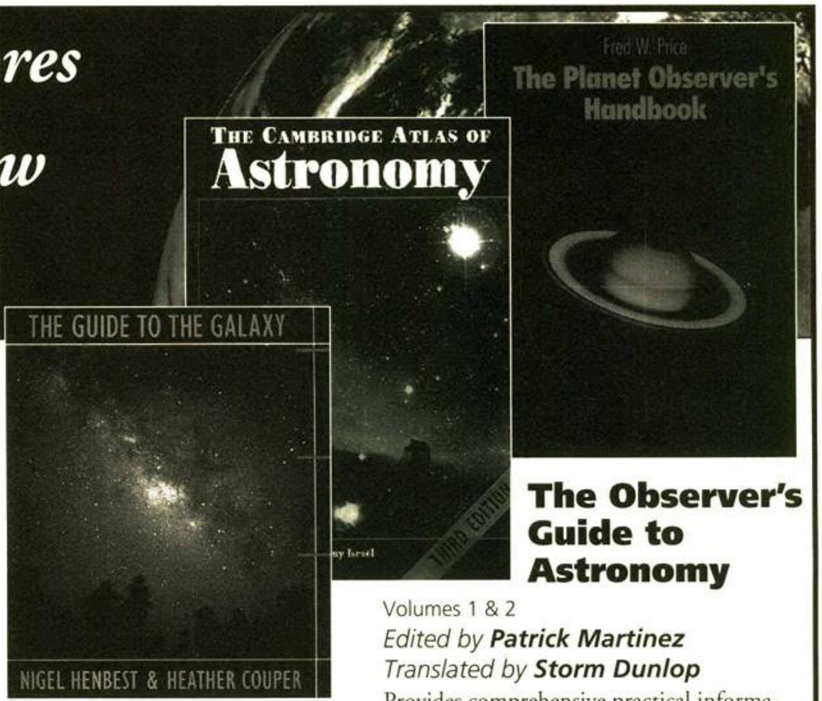

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–*Mark J. Coco, Astronomy*

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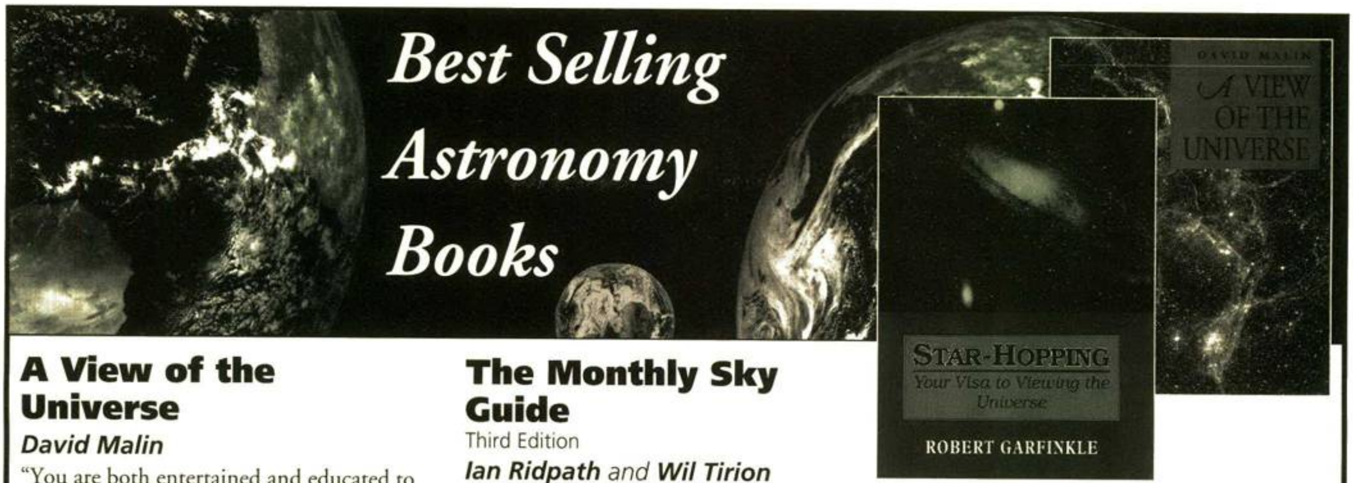

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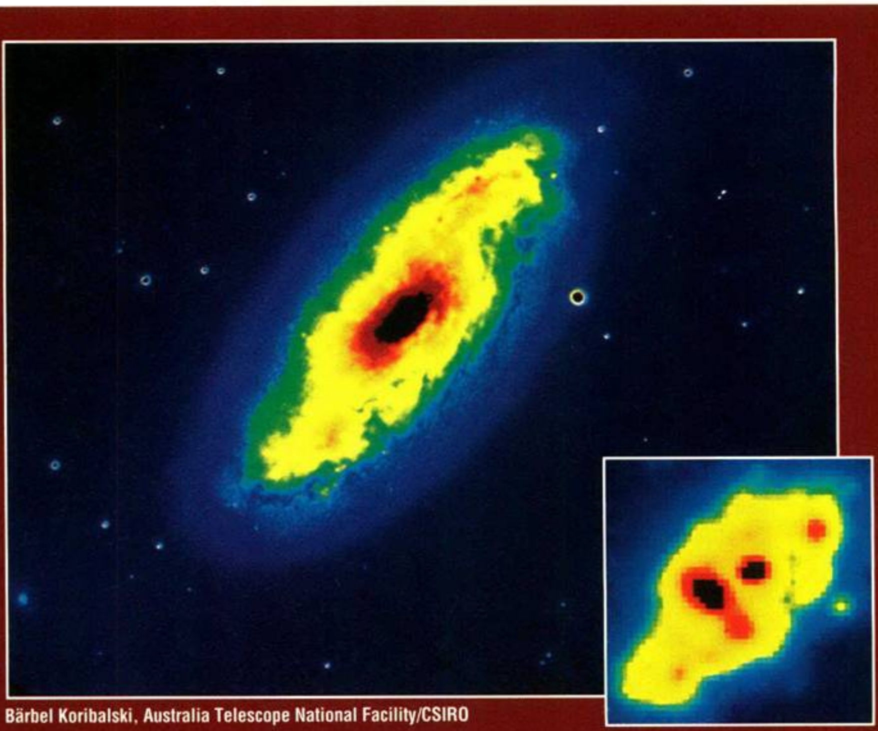
Santa Fe, New Mexico, and his colleagues have spotted ejections of gas from the corona that reach speeds of over a million kilometers per hour. These high-latitude coronal mass ejections travel faster than almost all the coronal mass ejections observed near the plane of Earth's orbit. These unprecedented measurements of ejections at different latitudes give solar astronomers an opportunity to determine what mechanism accelerates the coronal gas as it escapes the Sun's gravity.

The spacecraft is now making its way north and will cross the plane of Earth's orbit in February 1995 before passing over the Sun's north pole in the summer of 1995.



Bärbel Koribalski, Australia Telescope National Facility/CSIRO

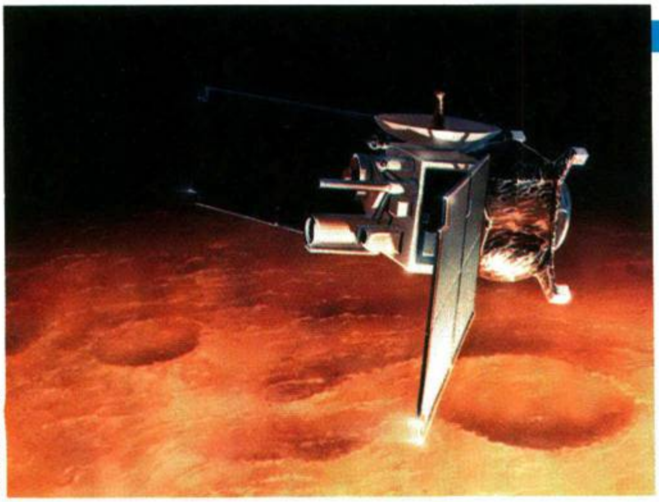
SEEMINGLY MILD MANNERED, GALAXY NGC 1808 is actually an active, "starburst" galaxy according to recent research by astronomer Bärbel Koribalski of the Australia Telescope National Facility in Epping, New South Wales. Koribalski used the 3.5-meter New Technology Telescope at La Silla, Chile, to image the galaxy, a 10th-magnitude object in Columba, and then looked closely at its nuclear region (right). There he found "hot spots" — luminous HII regions — near the galaxy's center, along with a quickly rotating ring of gas, a conglomeration of supernova remnants, a warped disk of gas, and a focused jet of gas extending into the galaxy's halo. All of these phenomena suggest energetic activity in the nucleus of this galaxy, perhaps powered by a central black hole.

Surveyor Sets Sights on Mars

With the selection in July 1994 of Martin Marietta as a prime contractor, the Jet Propulsion Laboratory has formally started NASA's Mars Surveyor program. The decade-long effort will see a fleet of orbiters and landers launched toward the Red Planet every 26 months through 2005. The first craft, an orbiter called Global Surveyor, has instruments duplicating all but two of those on board the ill-fated Mars Observer spacecraft. Besides carrying a camera for mapping, Global Surveyor will identify surface mineral content with a thermal emission spectrometer, use a laser altimeter to construct topographic maps, seek evidence for any past or present magnetic fields with a magnetometer/ electron reflectometer, and detect variations in the planet's gravitational field with an ultra-stable oscillator used in radio science experiments. The spacecraft also carries a communications system to relay data from future landers.

Global Surveyor will be launched in November 1996 on a Delta II expendable rocket, spend 10 months in transit to Mars, and then enter a polar orbit around the planet in September 1997. For four months, Surveyor will circularize its orbit by aerobraking, a technique that uses atmospheric drag to modify the shape of an orbit. The mapping mission starts in January 1998 and continues for a full Martian year, about two Earth years.

Future Surveyor launches — in 1998, 2001, 2003, and 2005 — will include landers. These landers will be based on the Mars Pathfinder rover, due to be launched in 1996. Small orbiters launched in 1998 and 2003 are slated to carry any Mars Observer experiments not flown on Global Surveyor and serve as data relay stations for future international missions. ☐



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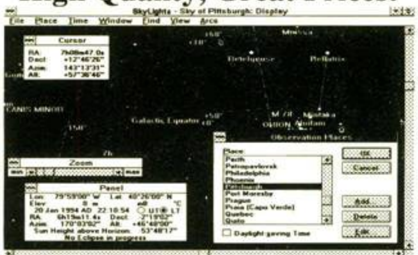

RA: 7h08m47.0s
Decl: +12°46'26"
Azm: 143°13'31"
Alt: +57°36'46"

Lon: 79°59'00" W Lat: 40°26'00" N
20 Jan 1994 AD 22:10:54 ○ UT ● LT
RA: 6h15m11.4s Decl: 2°19'02"
Azm: 170°03'02" Alt: +46°48'00"
Sun Height above Horizon: 53°48'17"
No Eclipse in progress

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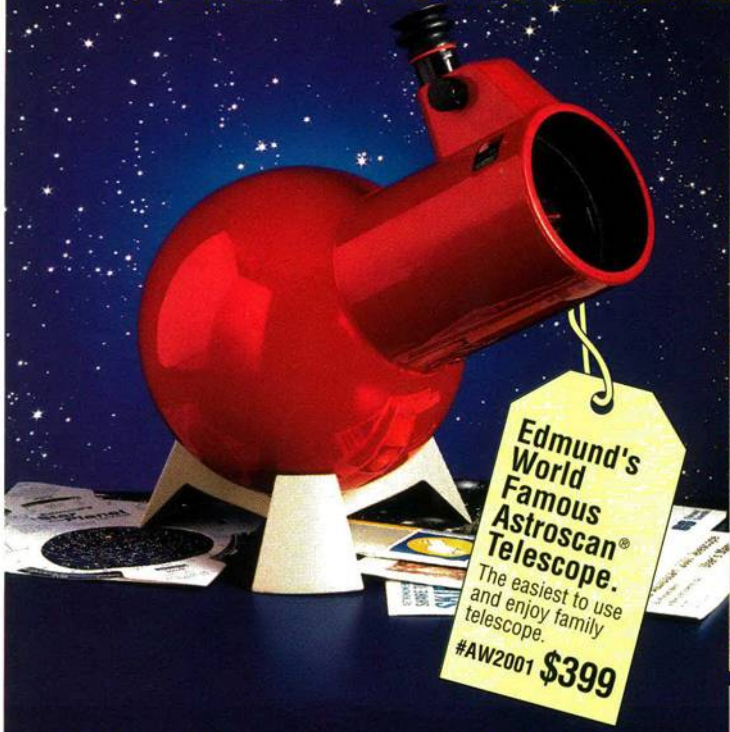
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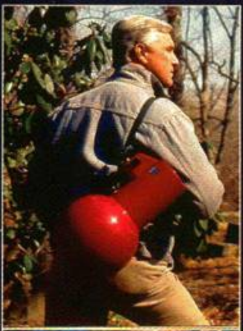

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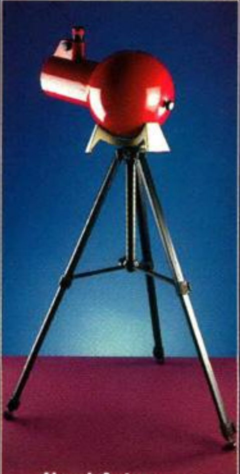

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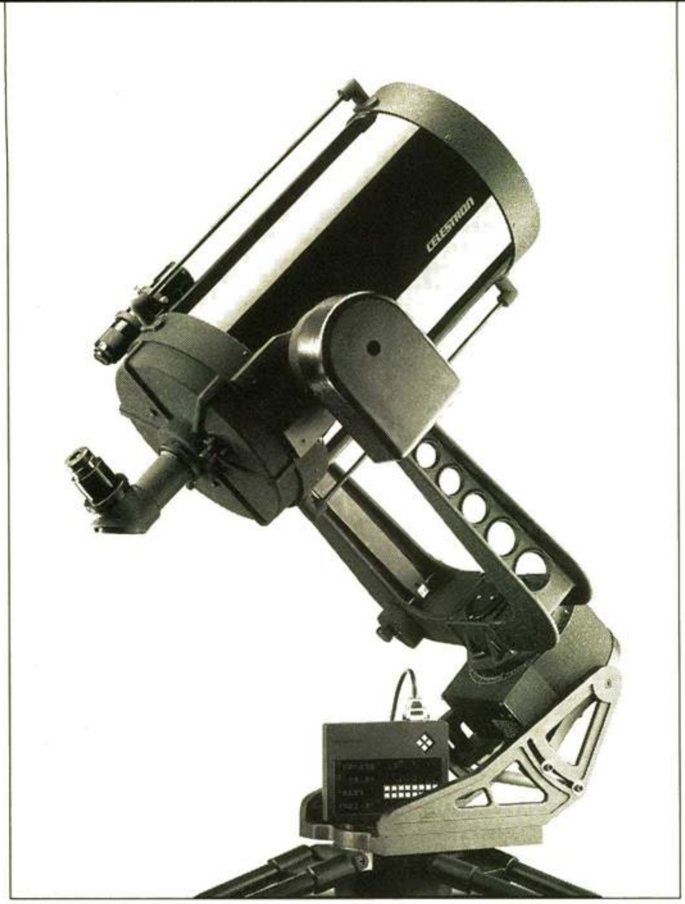

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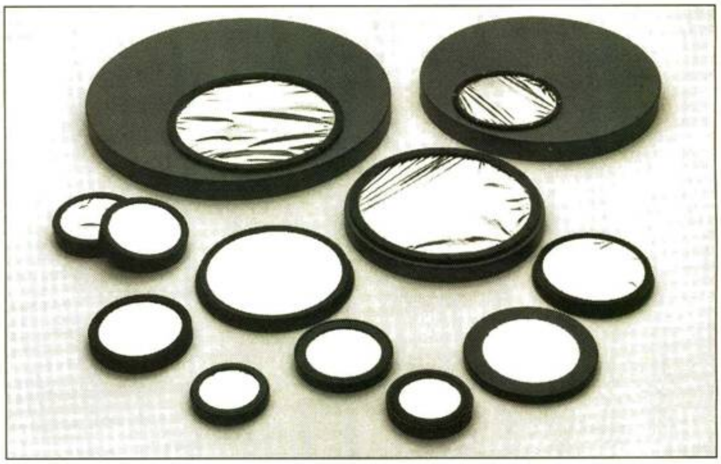

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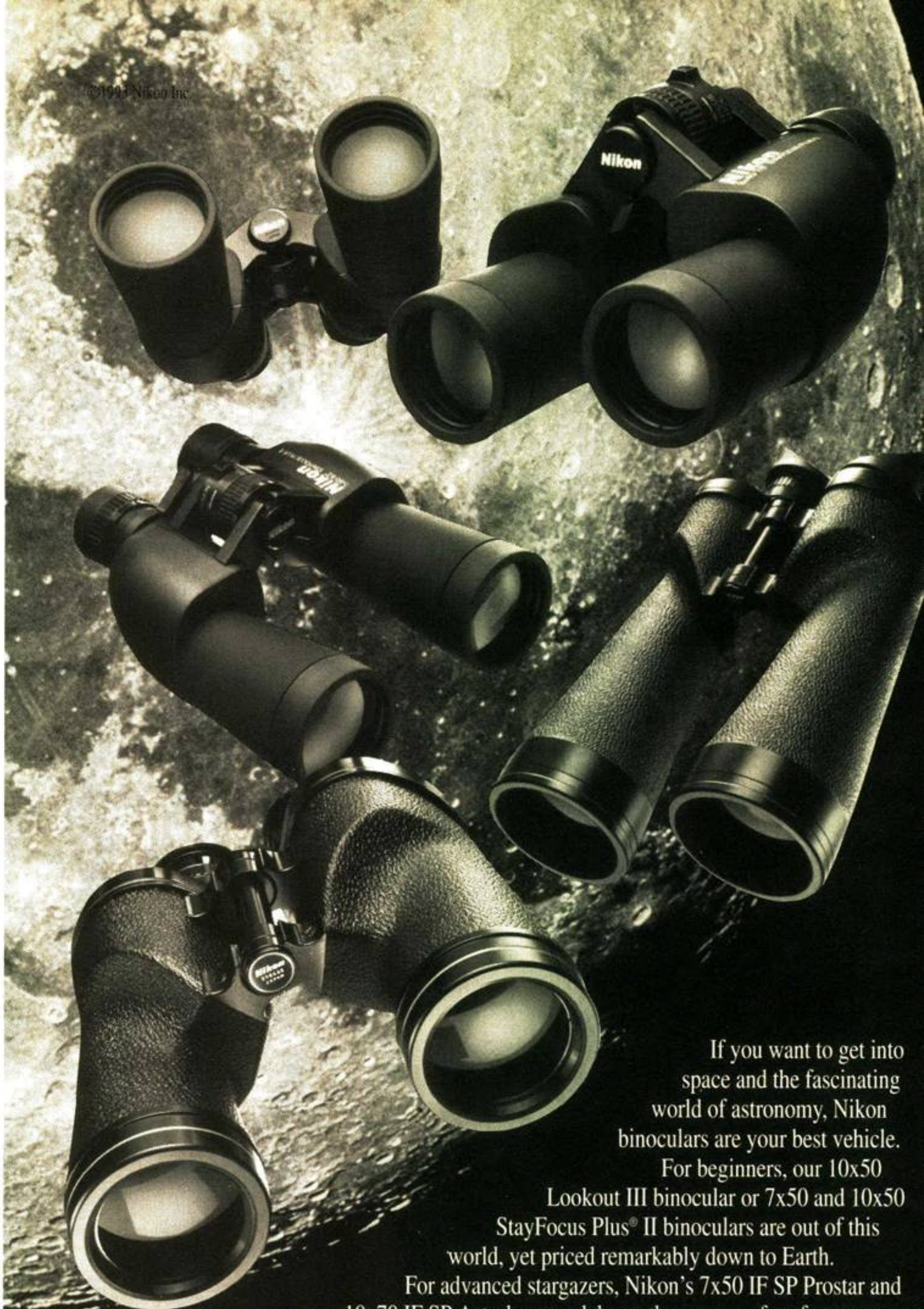
(continued on page 114)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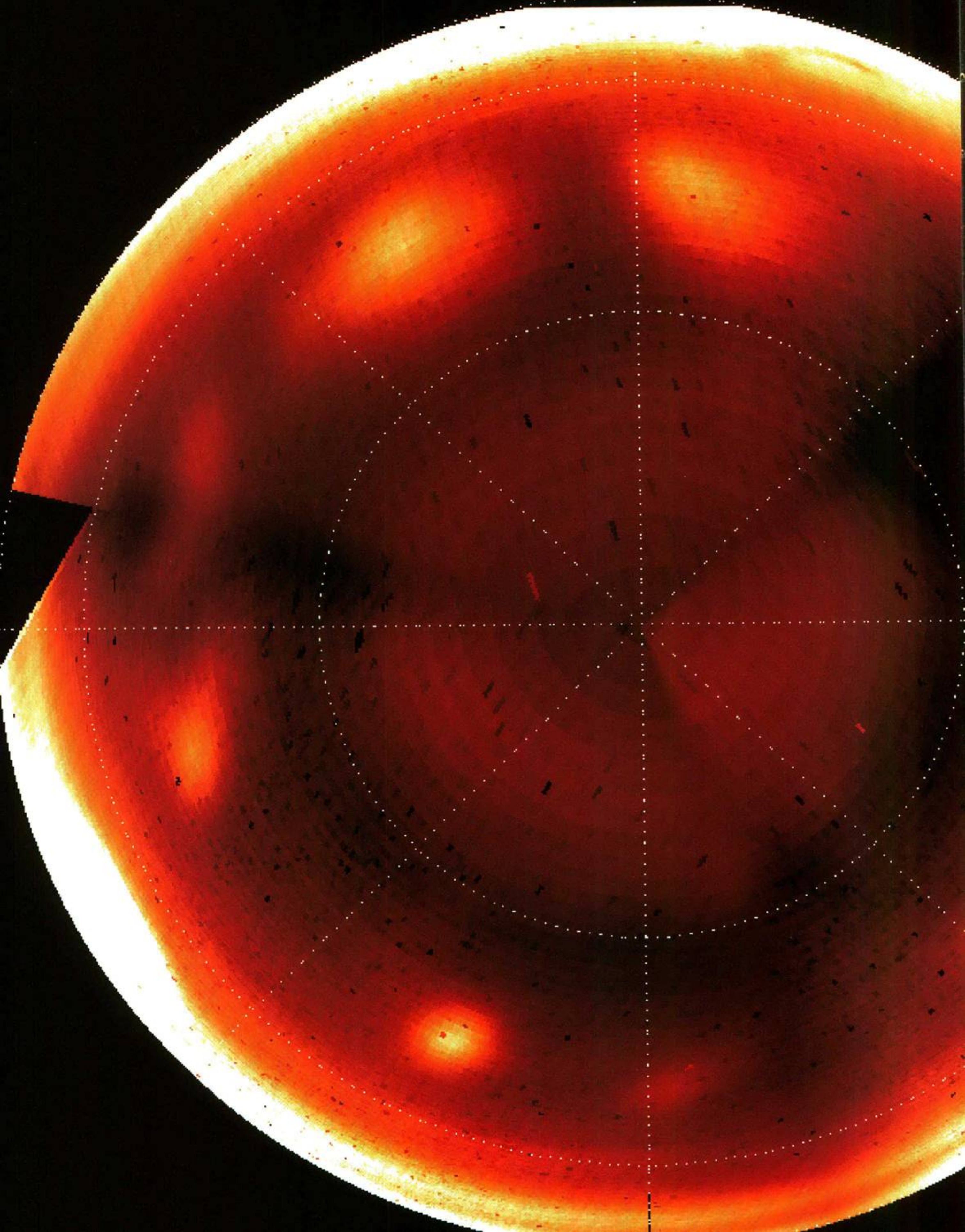
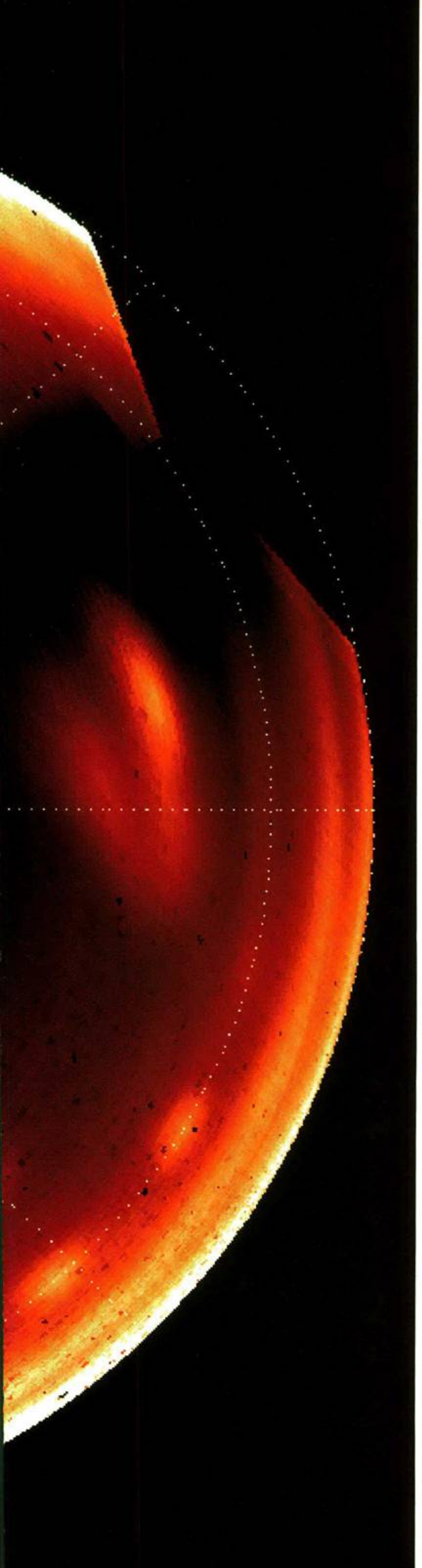
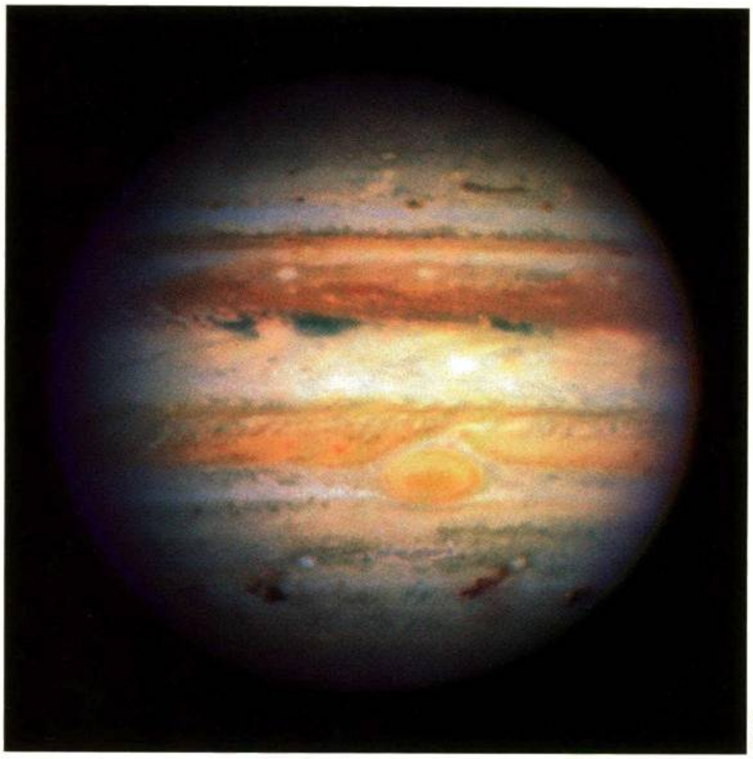






STScI

Jupiter's Smash Hit

When the comet struck Jupiter, pre-crash expectations were among the casualties.

by Robert Burnham

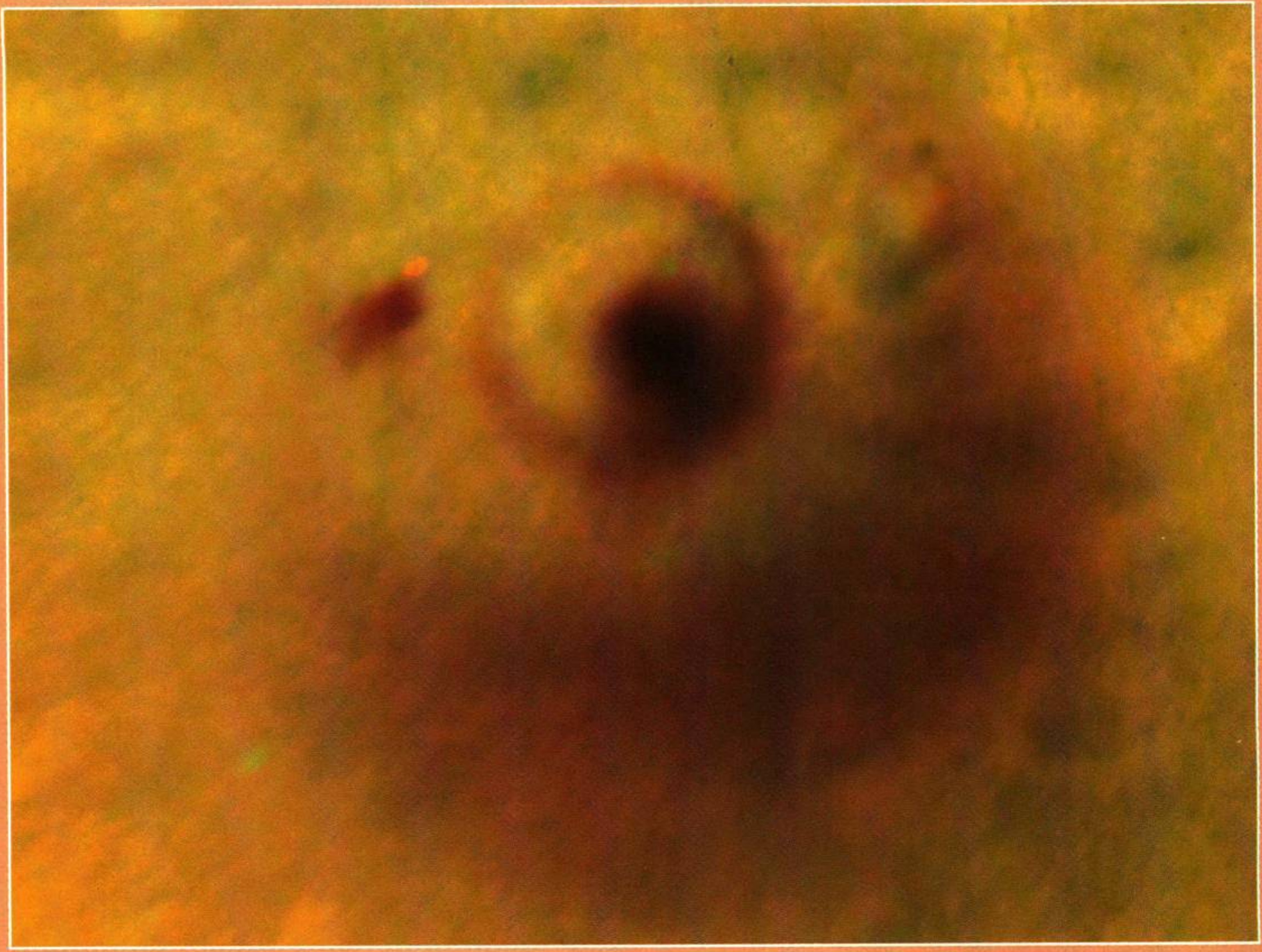
As the weeks passed following the crash of Comet Shoemaker-Levy 9 with Jupiter, planetary scientists struggled to understand what had happened. Thanks to a worldwide collaboration among observers, there's no lack of data to sift, organize, and study. The picture that's emerging from the data, however preliminary, highlights several surprises. In fact, many scientists feel that both the comet and Jupiter turned pre-crash expectations upside down.

The impacts were huge. Just before the strikes began, some scientists were predicting the show would fizzle. The comet's 23 fragments, they said, were just small clumps of weakly cohesive debris. Then fragment A, first to hit, sent a hot plume high enough above its farside impact site to be visible from Earth over the Jovian horizon. Shortly after, the site itself rotated into view and everyone could see a large dark smudge where the fragment had struck. The word "fizzle" abruptly

IMPACT SITES RING THE JOVIAN SOUTH POLE. Scientists wrapped three near-infrared images of Jupiter (taken with the 200-inch Hale telescope) onto a globe (left) and turned it to place the south pole in the center. Above: the Hubble Space Telescope saw sites A, E/F, H, and Q_1 (left to right) on July 22.

Palomar Observatory

Why were the spots so dark?



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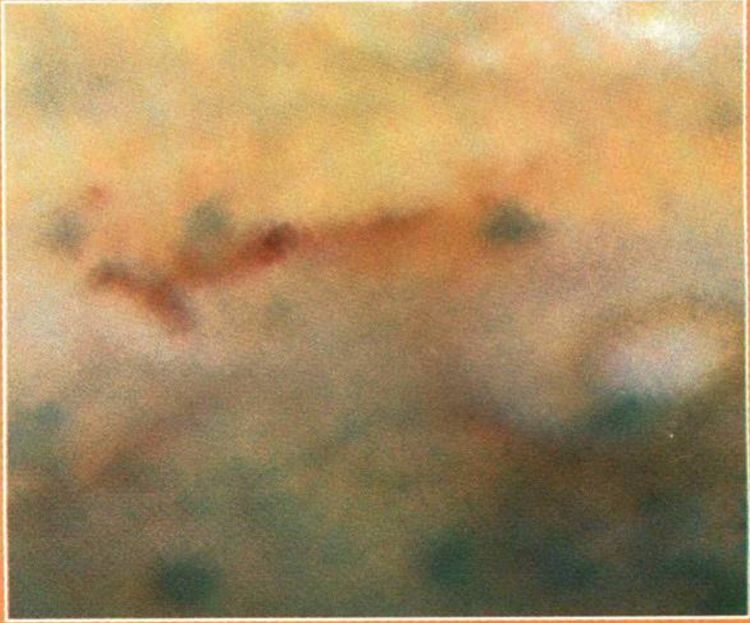
WHY NO WHITE CLOUDS? Scientists were surprised that the impact sites remained dark in visible light because re-crash predictions said that material brought up in the fireball plumes ought to condense into white clouds.

The G site was as large as Earth and displayed a complex shape. Taken 90 minutes after the strike, the image above shows the dark central impact site surrounded by a thin ring, probably an expanding sonic boom. The diffuse, dark crescent is likely made of sulfur particles sprayed from the impact site back along the fragment's incoming track. (The small dark spot immediately to the left of the thin ring is where the D fragment struck.)

The A impact site, seen in visible light (right) and through a methane-band filter (six images, far right), underwent constant changes during the week after the strike.



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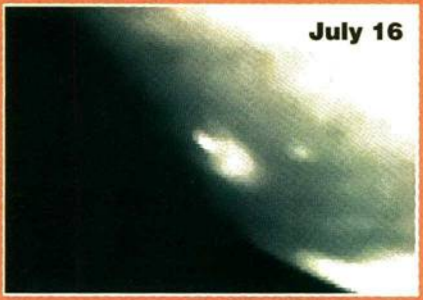

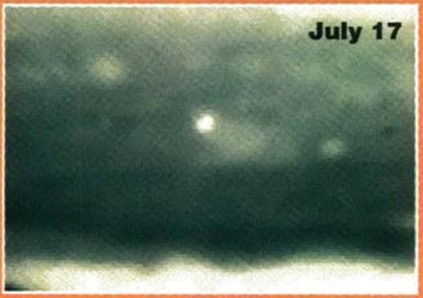

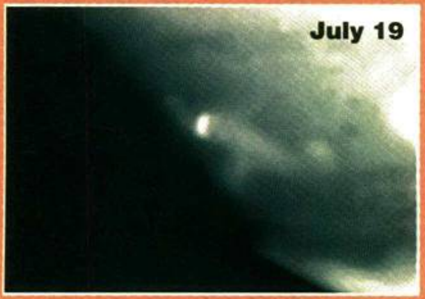

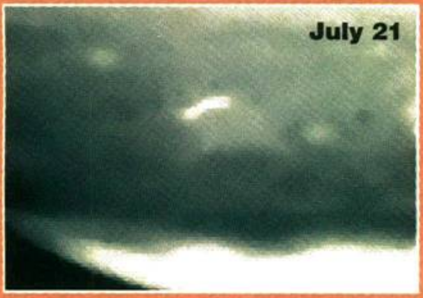

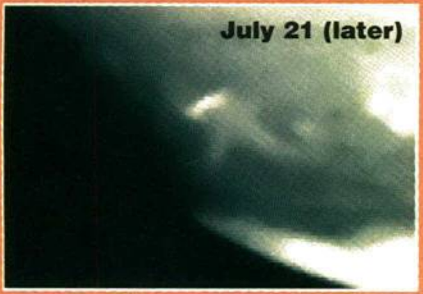

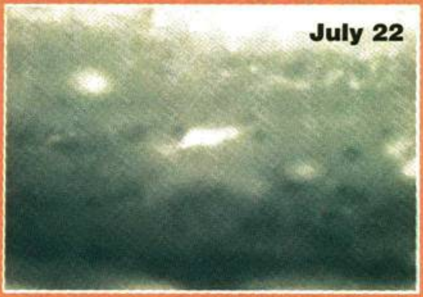

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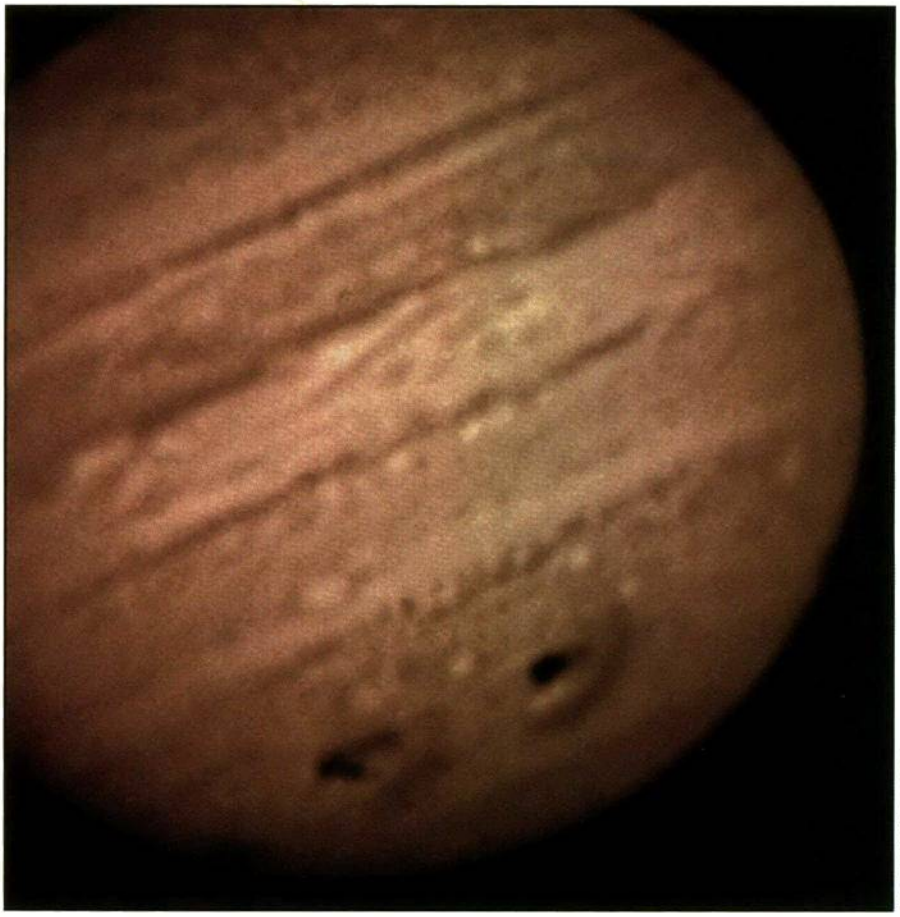


Pic du Midi Observatory

BIG HITS CROWDED JUPITER all during impact week. This image, taken late on July 20, shows the fresh Q_1 impact site just coming into view at lower left, with the older G/D and L sites on the disk. The K site is a small nick just visible on the right-hand limb.

disappeared from observers' vocabularies.

The smudges didn't smear out quickly. "I thought the impact sites on Jupiter would probably all blend together into a new band in about a week or so," says Kevin Baines of the Jet Propulsion Laboratory. "But it's remarkable — a month after the hits, most are still coherent."

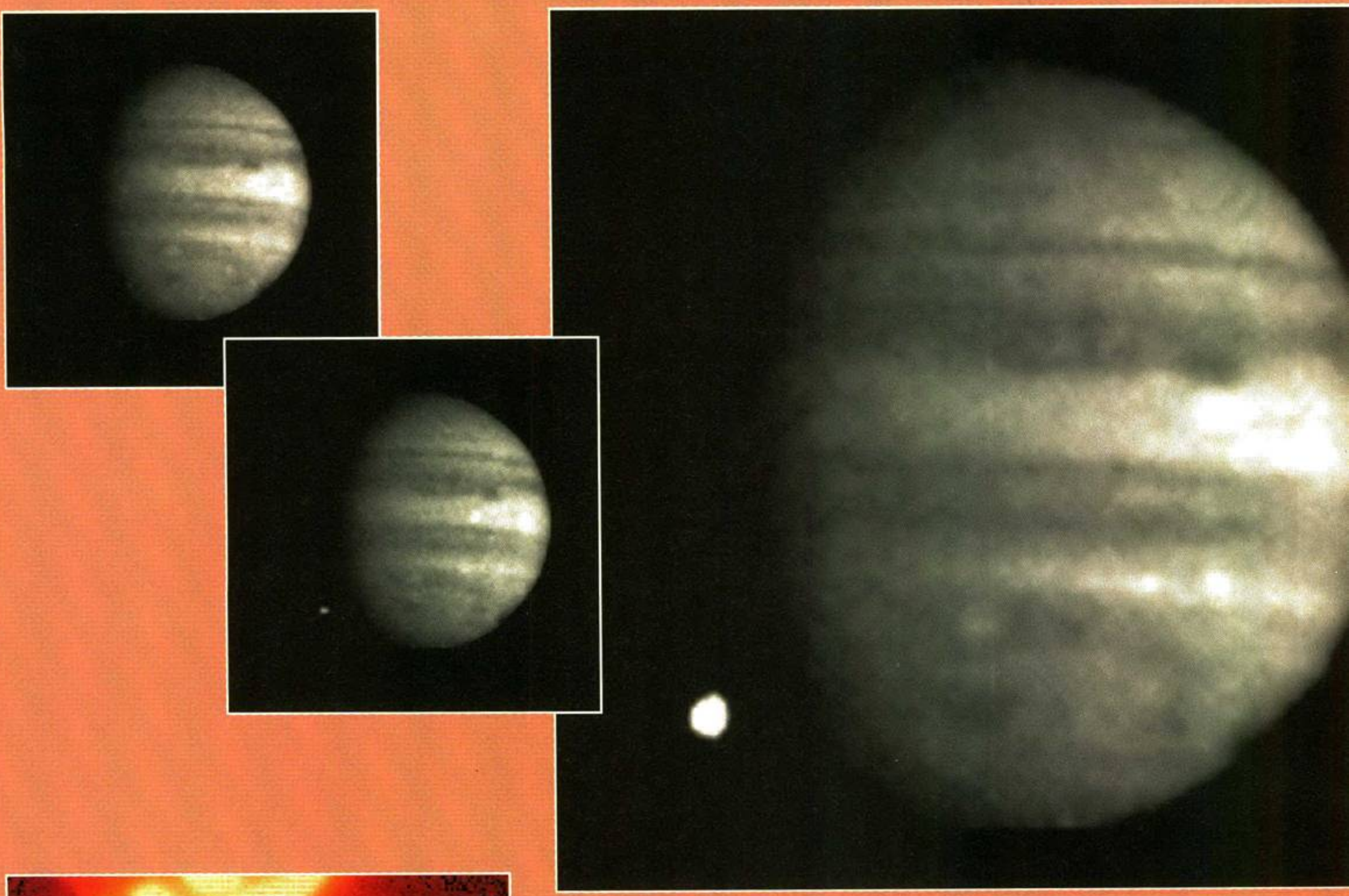
The smudges have endured because they lie in Jupiter's stratosphere, a region with little vertical motion. Just as volcanic dust injected into our stratosphere can remain suspended for years, scientists now expect that at least some Jovian debris will hang around a long time.

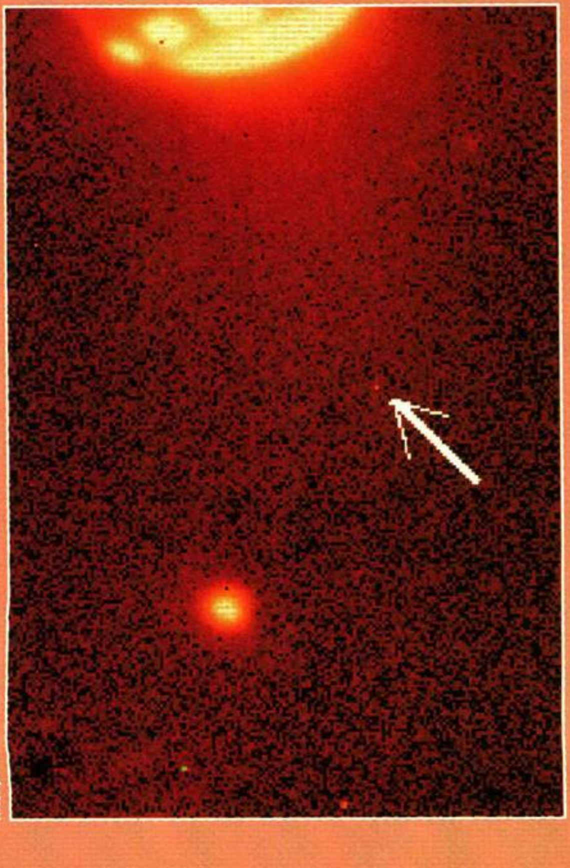
The smudges may change periodically. "These things are the highest structures we've ever seen in the Jovian atmosphere," says Sanjay Limaye of the University of Wisconsin. He is investigating whether the spots, which stand above the cloud deck and are the tops of long columns of debris extending down into Jupiter, may change rhythmically. "They may be a little like thunderstorms — their top gets blown off from time to time." The long entry corridor at each strike site, filled with comet debris, may behave like an enormous piston that periodically raises up an anvil-head and then sinks again, leaving the top to elongate and blow away.

The fragments exploded at or just below the cloud tops. This disappointed many who hoped the impacts would dredge up deep Jovian material. In particular they hoped the impacts would reach Jupiter's water-rich lower atmosphere. Instead, scientists saw no evidence of Jovian water. Some was detected at the G and K impact sites by observers aboard the Kuiper Airborne Observatory (see page 46), but it vanished quickly and probably came from the fragments themselves.

Scientists did detect evidence of ammonia, sulfur, hydrogen sulfide (a first for Jupiter), ammonium hydrosulfide, and helium. These resulted from the interaction of

Galileo's ringside seat





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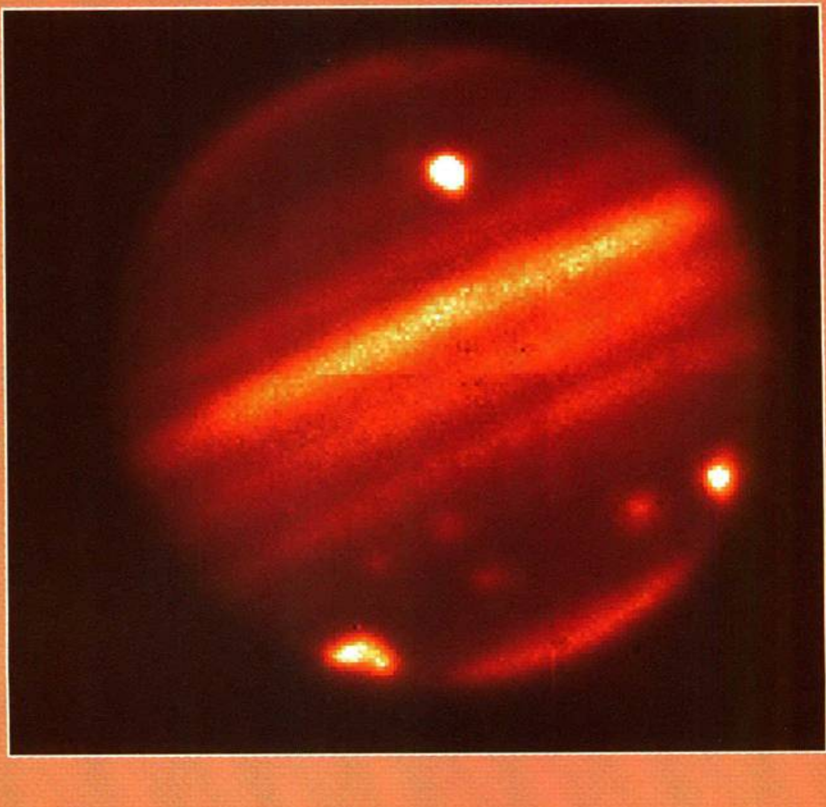
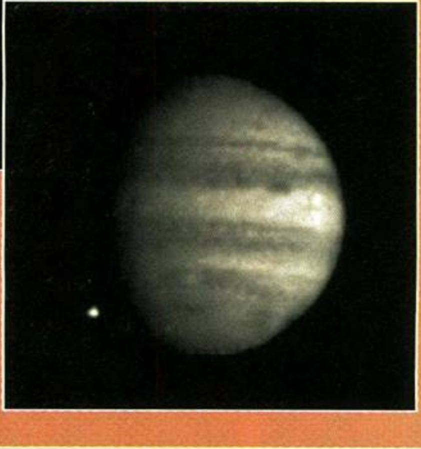


APO

FRAGMENT W IMPACTED just like the others. But its demise on July 22 was photographed by the Galileo spacecraft, then 148 million miles from Jupiter (left). Galileo's four images were snapped at 2.3 second intervals and revealed that the flash — about 1st magnitude as seen by the spacecraft — grew and faded quickly.

A few minutes before the impact of fragment K, NASA's Infrared Telescope Facility recorded the tiny fragment (arrow, bottom left). Jupiter lies at the top of the frame.

After the impact, the still-hot K site shone brightly in the infrared when it rotated into view (bottom center). The view at bottom right shows a large cloud of warm debris (blue area) expanding from the K impact site.



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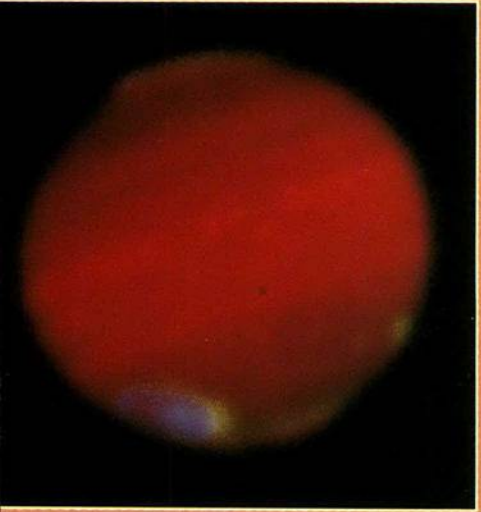

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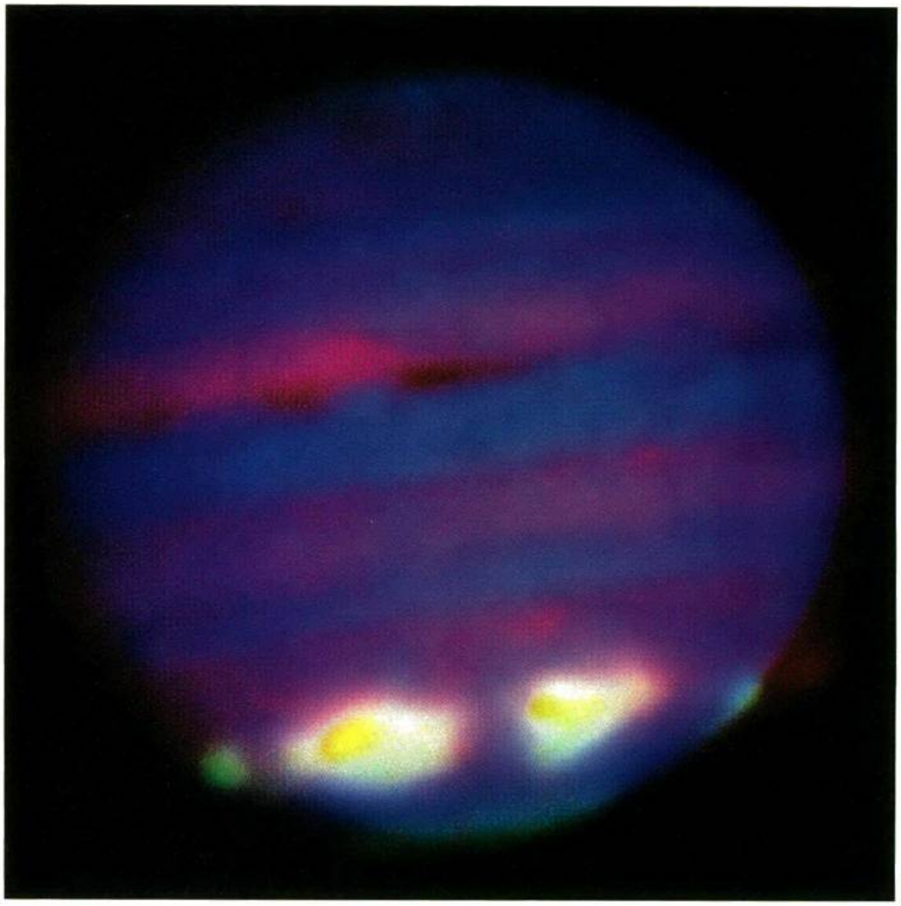


ESO

IMPACT SITES GLOW WARM AND BRIGHT. Jupiter looks bizarre in this composite false-color image taken July 22. It combines observations at red and infrared wavelengths taken on three different telescopes simultaneously.

Jupiter's clouds and atmosphere with the hot plume from the impacts.

No apparent "seismic" waves. Scientists also expected the impacts to send shock waves through Jupiter's atmosphere, revealing its inner structure as earthquake waves show the interior of Earth. A shock wave *was* detected at the violent G impact site, but it was only a sonic boom. If the impacts did cause deep waves, they have proven extremely subtle to detect, although some observers hold out hope that careful image processing may yet reveal them.

Since the fragments exploded higher up than most scientists had predicted, it suggests they were relatively small and uncohesive. In fact, the "rubble-pile" models championed by some researchers — but dismissed right after the first impacts — may turn out to be correct after all.

Puzzling dark rings. Surrounding many impact sites were large, faint, dark rings of unknown origin. These showed up in some images and have been noted visually by some observers. Limaye is collecting reports of these and requests that observers who have images or drawings showing these rings contact him directly. (His mail address is Sanjay Limaye, University of Wisconsin, 1225 W. Dayton St., Madison, WI 53706, or via the Internet at sanjay@ssecmail.ssec.wisc.edu.)

As scientists pore over their data and refine their understanding of comets and Jupiter, the greatest legacy of the comet may not be shattered theories but a safer Earth. The sonic booms had scarcely quit echoing in Jupiter's atmosphere when Congress directed NASA to investigate what it would take to detect any asteroids or comets on a collision course with Earth. In 1992 NASA presented just such a plan, called Spaceguard, but it was largely ignored by politicians as irrelevant. Now brought up to date, Spaceguard will likely get a far more receptive hearing. ☐

THE NEW STARS OF M42

Cyril Cavadore, Patrick Martinez, and Mathieu Sénégas

Until now, no one has seen the birth of a star. New results from Hubble have caught the Galaxy's newborn as they join their starry kin.

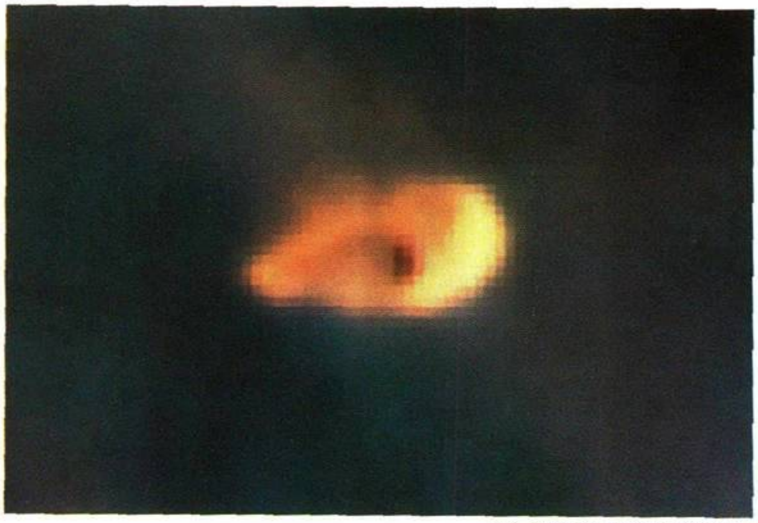
by Jean-Pierre Caillault

Fuzzy little ovals. Blots of orange light. They resemble specks of one's lunch dropped accidentally onto the photo.

Images of the central area of the Orion Nebula (M42) taken last December with the rejuvenated Hubble Space Telescope (HST) are not, however, plagued by defects from the darkroom or the lunch table. Instead, the fuzzy ovals are protoplanetary disks, the first solar-systems-in-the-making viewed from a distance of 1,500 light-years.

Astronomers investigate the Orion Nebula and its many young stars because it is the largest and most active region of starbirth in our part of the Galaxy. The vast sheets and clouds of gas and dust comprising the Orion Nebula, visible to the naked-eye as a hazy "star" in the Sword of Orion on dark November evenings, are slowly coalescing into infant suns. The region is the richest known in stars, in fact, with more than 4,000 stars per cubic light-year packed into the center of the nebula. Because the gas-into-stars machinery is operating on such a massive scale in the Orion Nebula, the area offers the best available laboratory for astronomers hoping to understand both the young stars and their possible planetary systems and the hot stars embedded in the nebula.

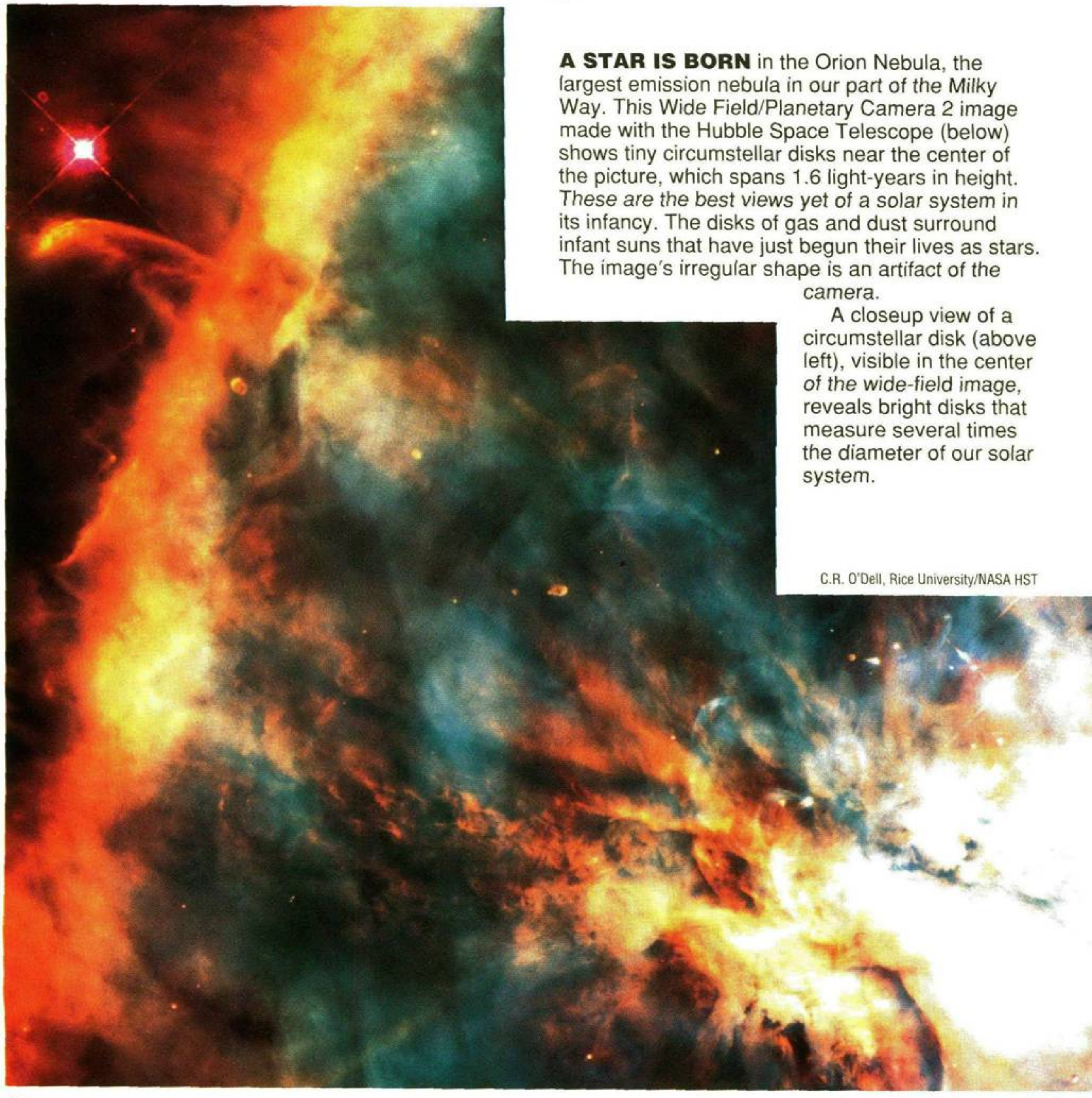
But do Orion's young stars even *have* planets? The question feeds into age-old wonder about life on other planets. To investigate the existence of possible planetary systems in the Orion Nebula, Rice University astronomers C. Robert O'Dell and Zheng Wen (now at the University of Kentucky) began the imaging survey in 1989 that produced last December's images of protoplanetary disks, or "proplyds," as researchers call them. O'Dell examined 110 stars and found gas and dust, "the



C.R. O'Dell, Rice University/NASA HST

ingredients for making planets," around 56 of them. "This provides strong proof that protoplanetary disks are a common product of star formation," says O'Dell.

The discovery of the protoplanetary disks meshes well with the understanding of how the solar system formed some 4.6 billion years ago. A disk similar to those we now see surrounding the new stars of Orion coalesced into the Sun's attendant debris — the planets, comets, and asteroids. The disk forms because some of the gas and dust has such a large centrifugal force that it cannot be funneled into the young star itself, so it remains behind to form a disk. According to O'Dell, the proplyds probably contain materials much like those in the solar nebula —



A STAR IS BORN in the Orion Nebula, the largest emission nebula in our part of the Milky Way. This Wide Field/Planetary Camera 2 image made with the Hubble Space Telescope (below) shows tiny circumstellar disks near the center of the picture, which spans 1.6 light-years in height. These are the best views yet of a solar system in its infancy. The disks of gas and dust surround infant suns that have just begun their lives as stars. The image's irregular shape is an artifact of the camera.

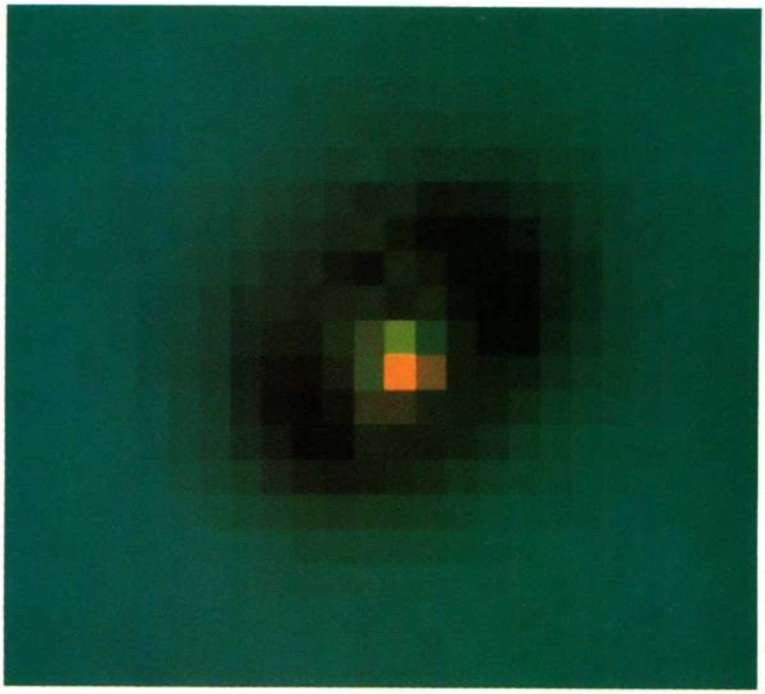
A closeup view of a circumstellar disk (above left), visible in the center of the wide-field image, reveals bright disks that measure several times the diameter of our solar system.

C.R. O'Dell, Rice University/NASA HST

carbon, silicates, and other elements and compounds similar to those on Earth. The mass in the outer rims of the proplyds alone probably amounts to several times that of Earth. One of the most clearly visible disks measures 53 billion miles across, or 7.5 times the diameter of the solar system (see right). Seemingly supporting this observation, another, closer protoplanetary disk was observed earlier around the star Beta Pictoris and dusty disks have been spotted around Fomalhaut, Vega, and other stars. From all of this evidence, it seems clear that we are seeing solar systems in the making. No other explanation appears to be plausible.

The suggested abundance of extrasolar planets, implied by the proplyds, points up the possibilities for large numbers of planets supporting living beings elsewhere in the Galaxy and the universe. Previously, astronomers' ideas on extraterrestrial life were limited to statistical shell games based on probabilities. The probabilities already indeed look good: One needs only a tiny fraction of the planets that presumably exist throughout the cosmos to meet the right conditions for huge numbers of inhabited planets. Despite the favorable odds, however, much of the hypothesizing was close to guesswork. Now that guesswork is supported even more strongly by mounting evidence that favors the existence of life throughout the cosmos.

"At least half of the young stars have the potential for forming planets," says O'Dell. And a measurable fraction of those planets would have the right conditions for the *formation* and evolution of living beings.



C.R. O'Dell, Rice University/NASA HST

THE YOUNGEST KNOWN PROTOPLANETARY SYSTEM appears as a dark oval with a faint glow in its center. The glow is a cool red star between 300,000 and 1 million years old; the dusty disk, stretching 56 billion miles across, appears dark because it is far from hot stars that could ionize it and cause it to glow.

Proplyds are only one object being studied in the recent renaissance of stellar research centered on the Orion Nebula. Several astronomers are focusing their attention on the extremely hot and massive star Theta^1 C Orionis, the brightest star in the nebula's central star cluster called the Trapezium. This star — visible in backyard scopes at medium power — bathes the central area of the nebula in ionizing radiation and sculpts it with a powerful stellar wind, creating shock waves that slam into the gas and dust along their paths. We see these glowing shock fronts in large areas of the nebula like the familiar sheets and walls and small parts like the proplyds. This star, then, is instrumental in revealing the proplyds. The proplyds, in turn, tell us about the stars inside them, including their stars' radiation output and ability to regulate the way they spin.

Some of these odd revelations resulted from the work of my own research group, which includes Marc Gagné of the University of Georgia and John Stauffer of the Harvard-Smithsonian Center for Astrophysics. Recently we have observed the Orion Nebula with the high-resolution imager on board the ROSAT orbiting X-ray observatory. We needed the fine resolution of this combination to produce meaningful data in an area so jammed with stars. Our group detected more than 250 stellar X-ray sources in an area 25 foot square centered on the Trapezium. Most of these stars are low-mass, Sun-like stars. But some of them are hot, massive stars that include the brightest beacons in the Trapezium.

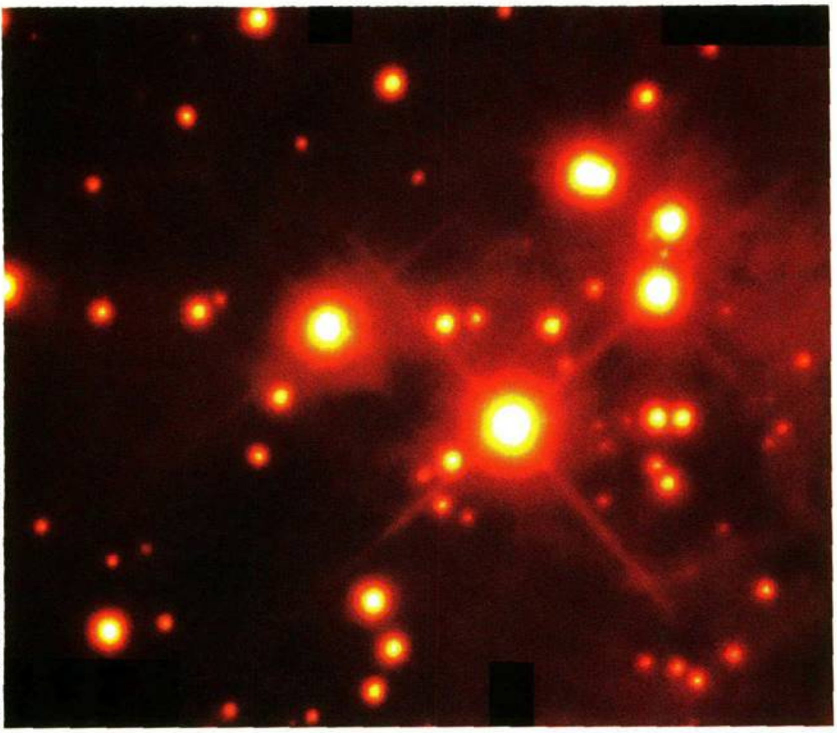
Not only is Theta^1 C Orionis the brightest star in the area in optical wavelengths, but it is a powerful X-ray emitter. It is an O7-type star with about 30 times more mass than the Sun and is seven times hotter, at about 40,000 K. The ROSAT observations of this star were taken over a period of 11 months, and we were startled to see that Theta^1 C Orionis changed its X-ray emission over this interval by about 50 percent. More recently a group of astronomers at the European Southern Observatory led by Otmar Stahl of the Landessternwarte Heidelberg-Königstuhl discovered that Theta^1 C Orionis varies its hydrogen and helium emission over a period of about 15 days. Once our group became aware of this, we searched for this period in the X-ray data and found that indeed the star's X-ray output parallels its hydrogen and helium emission. Adding to the evidence, Nolan Walborn of the Space Telescope Science Institute and Joy Nichols of Computer Sciences Corporation waded back through ultraviolet spectra taken with the International Ultraviolet Explorer satellite between 1978 and 1983 and found that the star's ultraviolet emission also varied over a roughly 15-day interval.

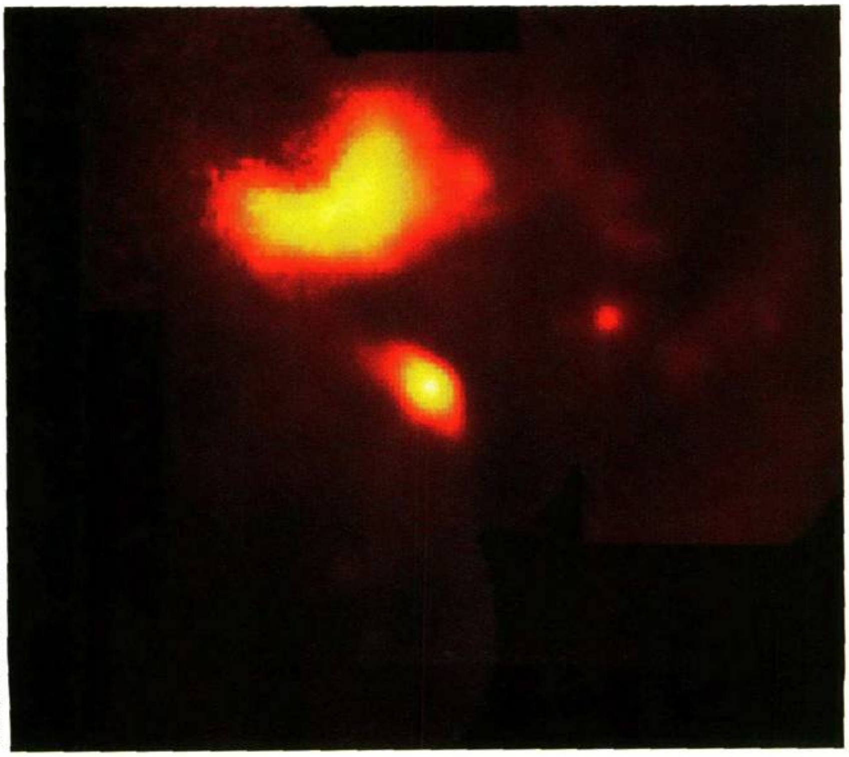
The question then arose: Why is this powerful star varying its energy output over a regular, short cycle? The answer seems to be that Theta^1 C Orionis is a highly magnetized, hot star with a strong stellar wind. The star's rotation axis is tipped to our line of sight and the star's rotation causes hot spots to move into view, regularly brightening the star. If this is the case, which astronomers currently believe it to be, then all of

Theta^1 C Orionis' energy output — in visible light, X rays, and ultraviolet — results from extended features tied to the surface of the star.

Once astronomers realized Theta^1 C Orionis ionizes everything near it, they sought more details on some of the objects being ionized. For example, Guido Garay of the Universidad de Chile led a team of astronomers who discovered a number of very small radio sources in the Orion Nebula. The nature of these objects was certainly mysterious, so Garay dubbed each class with an acronym based on its observational characteristics. Being an animal lover, Garay's stable of objects includes PIGs (partially ionized globules), DEERS (deeply embedded energetic radio sources), and FOXES (fluctuating optical and X-ray emitting sources)! In a follow-up project, Marcello Felli of the Osservatorio Astrofisico di Arcetri in Florence, Italy, and his collaborators have used the Very Large Array in New Mexico to discover a number of radio sources in the Trapezium, both thermal sources and nonthermal sources. The former consist of hot gas, and the latter have electrons interacting with magnetic fields. Many of Felli's thermal sources coincide with optical stars, which are thought to be other examples of circumstellar disks.

The research continues. Like O'Dell, Charles Prosser of the Harvard-Smithsonian Center for Astrophysics has used HST to look at the Orion Nebula. With the Planetary Camera and filters that excluded light from nebulosity, Prosser and friends found more than 300 stars packed into a small volume of about 2.3 cubic light-years inside the Trapezium. Their survey includes all low-mass stars down to about 15 percent of the Sun's mass. They have found that


Mark McCaughrean, Max Planck Institut für Astronomie

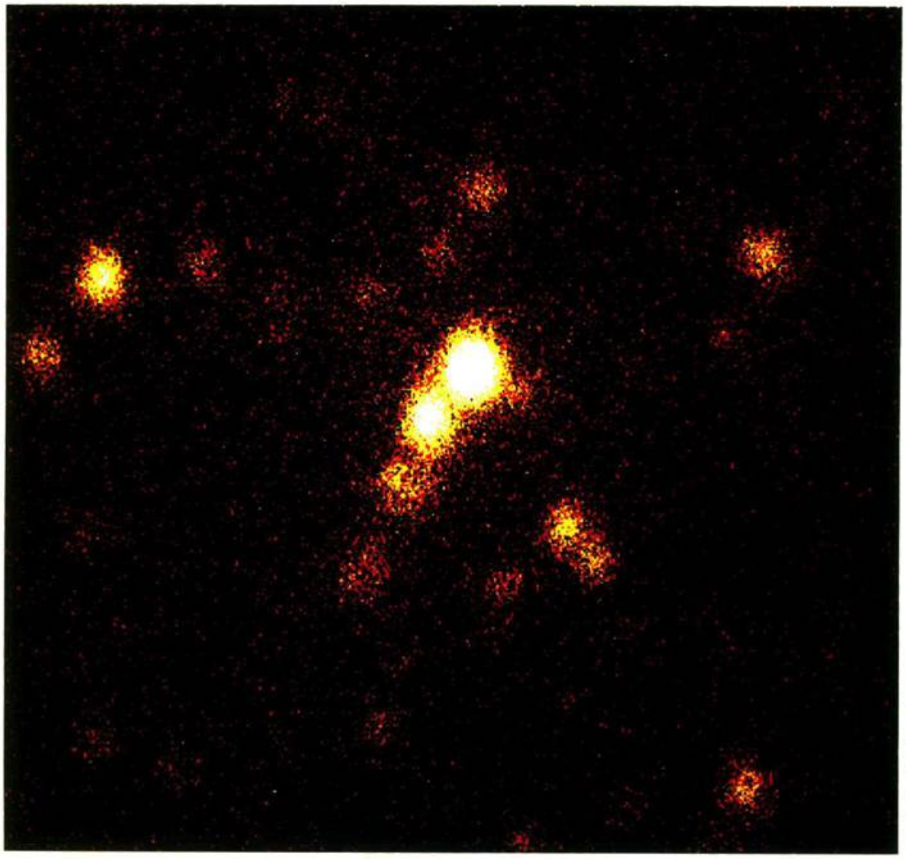

T.L. Hayward, J.R. Houck, and J.W. Miles, Cornell Univ.

THE HIGHEST RESOLUTION IMAGE of the Trapezium Cluster ever produced shows a tangle of stars at the heart of the Orion Nebula (above left). Taken at the near-infrared wavelength of 2.2 microns, it depicts faint, young stars near bright O and B stars that produce most of the radiation inside the cluster. This view confirms the Trapezium Cluster as the densest young star cluster known in the Milky Way.

Warm dust in the center of the cluster glows brightly in an infrared image made at 11.7 microns (left). The hot star Theta^1 C Orionis heats the dust, causing it to shine in the infrared. This picture reveals for the first time small, dusty objects that correspond to the protoplanetary disks visible in the Hubble Space Telescope images (see pages 42 and 43).

80 percent of these stars are less than a million years old. They too found a few proplyds being "lit up" by Theta^1 C Orionis. The research by Prosser has given us a penetrating look inside Orion's womb.

This central area of the Trapezium has also received scrutiny in the midinfrared wavelengths of 8.8 and 11.7 microns. Tom Hayward, James Houck, and John Miles of Cornell University used the 200-inch Hale telescope on Palomar Mountain to create images that reveal dusty counterparts to objects previously seen only at optical and radio wavelengths. The images show several parabolic arcs aiming away from Theta^1 C Orionis, further evidence of the powerful stellar wind blowing from the star. The dust may have been pushed into glowing gas by Theta^1 C Orionis' wind or produced in the glowing gas clouds. The ability to separate the two components shows the value of observations in the midinfrared and the need for high-resolution observations.


J.P. Caillault, Univ. of Georgia

BRIGHT X-RAY SOURCES SCATTER around the star Theta^1 C Orionis (center). X-ray observations of the star from a number of researchers have helped to show that it is very energetic, rotates rapidly, and emits a powerful stellar wind.

Another infrared study, this one at the wavelength of 2.1 microns, reveals other details of the mysterious cluster embedded in the Trapezium. Stauffer, along with Mark McCaughrean of the Max Planck Institut für Astronomie in Heidelberg, Germany, used the 3.5-meter telescope at Calar Alto, Spain, to survey stars near the center of the Trapezium. Stauffer and McCaughrean discovered more than 100 stars in a region only 0.3 light-year across, which yields an astonishing density of nearly 4,000 stars per cubic light-year. This survey uncovered stellar counterparts to a large number of knots of gas observed with HST and by other methods. The discovery of stars corresponding to these knots means that probably hundreds of proplyds exist in the cluster, each a young star with a burgeoning solar system. Using the infrared and radio surveys and HST imagery, Stauffer has estimated and found that greater than 50 percent of the stars in the Trapezium Cluster have proplyds.

Astronomers now know that protoplanetary disks exist in great numbers, at least in the Trapezium Cluster inside the Orion Nebula. That, in itself, is a tremendous confirmation of our knowledge about how stars form and suggests that an overwhelmingly large number of planetary systems must exist in the Galaxy and in other galaxies. But that's not enough for some astronomers, who want to know how the proplyds affect the stars buried inside them and their ability to radiate energy outward. Suzan Edwards of Smith College and Steve Strom of the University of Massachusetts have studied solar-type stars in the Orion Nebula. They probed the role played by a circumstellar disk in regulating the spin of the star lying inside. They studied three dozen stars and found that stars with circumstellar disks have rotation periods of more than 4 days, while stars without disks spin more rapidly. The results suggest that a star's rate of spin doesn't speed up to normal until the circumstellar disk dissipates. When the star's radiation and stellar wind drive away the material, the star "spins up" at a much faster rate of rotation.

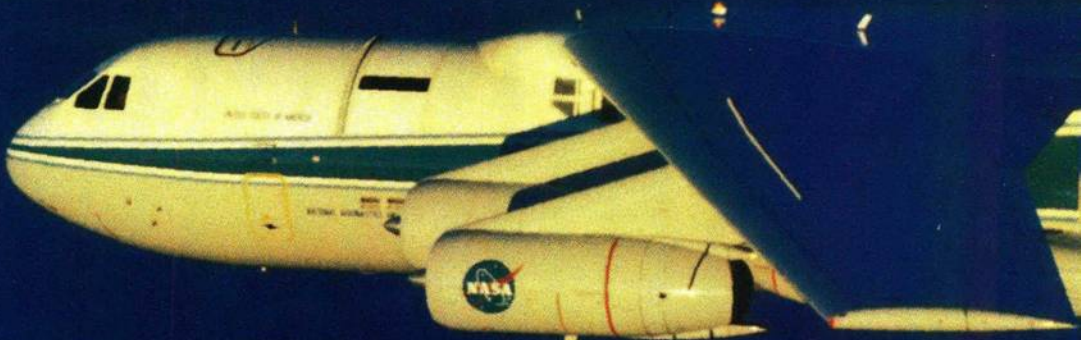
The star spins faster in part because its magnetic field rapidly decreases in strength. Such a drop ought to be discernible in X-ray emission, with the low-mass, Sun-like stars producing significant X-ray energy and the intermediate mass stars, those that have spun up, producing little or no X-ray emission. That's exactly what our team sees in the record of ROSAT X-ray observations of the Orion Nebula region.

Astronomers are rejoicing in the natural laboratory of the Orion Nebula, struck by the way theory and observation are coming together to show how stars are born and how they evolve toward life with a family of planets. No longer is Orion simply a beautiful light in the wintertime sky, a playland for exploring wisps and tendrils of nebulosity in the telescope. It is that, certainly. But it is also the place where we are documenting for the first time the first million years in the life of a star like our Sun. □

Jean-Pierre Caillault is an astronomer at the University of Georgia specializing in X-ray studies of the Orion Nebula and other star-forming regions.

TELESCOPES THAT *FLY*

by Sally Stephens



A star-forming region in Orion

Al Harper, Yerkes Obs.

Join a crew of astronomers on the Kuiper Airborne Observatory as they hunt for newborn stars.

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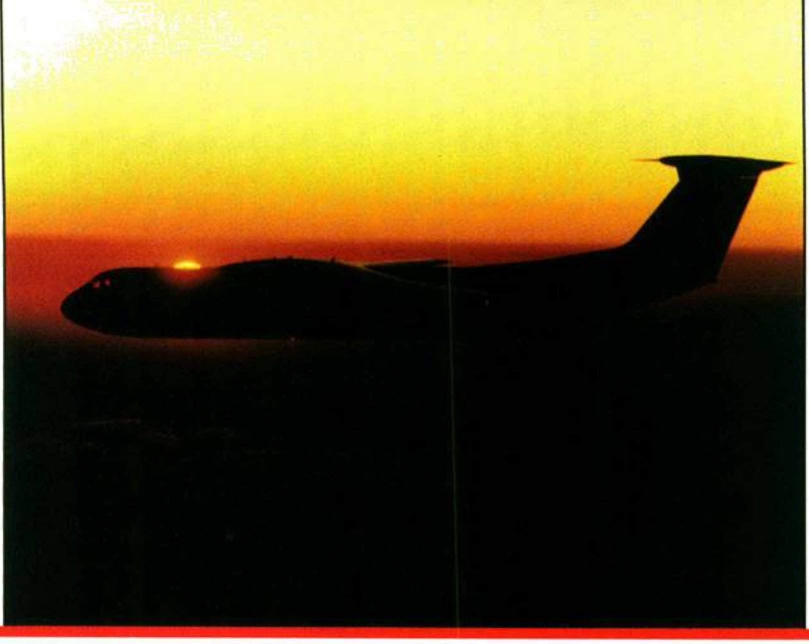
All images courtesy of NASA unless otherwise



"There's no way to do from the ground what we do up here," says Al Harper of Yerkes Observatory.

The Kuiper Airborne Observatory flies above more than 99 percent of Earth's infrared-absorbing water vapor, giving astronomers a clear window on the infrared universe.

Noise. Before anything else, that was what I noticed. Four powerful jet engines create a lot of noise. And a lot of vibration. The second thing I noticed were the oxygen masks, hanging like stalactites from the ceiling above the seats. As time passed, I realized that my feet were getting cold as the chill of the stratosphere seeped into the plane. Add air turbulence to the mixture, and I wondered how anyone ever thought they could do serious astronomy from an airplane. But that is exactly what we are here to do.

We had taken off at 10 o'clock at night from NASA's Ames Research Center near San Francisco, climbing rapidly as we headed south toward Los Angeles. At 33,000 feet while still gaining altitude, a door opens, uncovering the 36-inch telescope that looks out a hole in the side of the plane. Stars streak across the television monitor in the cabin like meteors. Once at the initial cruising altitude of 37,000 feet, the plane turns and heads for Arizona. The streaks stop as the telescope locks onto the first object of the night — the irregular galaxy M82, home to a recent burst of star formation.

Now traveling at a speed approaching 440 miles per hour, the astronomers on board begin their night of observations. Mounted in a pressure-sealed cavity just in front of the left wing, the telescope is completely isolated from the rest of the plane, supported on an air bearing and four large air bladders that absorb vibrations caused by the engines and air turbulence. Sensitive gyroscopes keep it pointed on target, sensing minute changes in its position and directing powerful electromagnets to nudge the 6,000-pound telescope back into place.

During the flight, the telescope appears to be moving constantly, rocking back and forth, sometimes wildly. But a quick glance at the television monitor used to guide the telescope shows rock-steady stellar images. Slowly I realized that it is the plane — and the people riding in it — that is moving back and forth as it encounters turbulent air; the telescope itself remains still, centered on the objects the astronomers have come to study.

The observers on tonight's flight are Al Harper of Yerkes Observatory and the University of Chicago, two of his colleagues, Bob Loewenstein and Joanna Lees, and one of his graduate students, Dave Cole. Harper sits in a row of three standard airline seats behind a rack of electronic equipment that controls the infrared camera he brought with him from Yerkes, now firmly attached to the telescope not more than four feet away. The square detector at its heart, one and a half inches on a side, consists of 64 tiny silicon cubes arranged in eight rows of eight columns. Each measures the intensity of infrared, or heat, radiation at wavelengths of 60, 100, or 200 microns, depending on the filter setting. Together they provide a map showing the brightness of infrared radiation in a star-forming region and, perhaps, will pinpoint the location of a newly formed star.

The KAO

For twenty years, astronomers like Harper have flown in the Kuiper Airborne Observatory (KAO), a modified C-141 military cargo plane, climbing nearly eight miles into the sky to study the heat radiated by planets and stars, nebulae, and galaxies. "There's no way to do from the ground what we do up here," Harper says. Water vapor in our atmosphere effectively absorbs all but a few select wavelengths of infrared radiation, preventing it from reaching even the highest mountaintops on Earth. But at its cruising altitude of 41,000 feet, the airplane — and the telescope it carries — flies above more than 99 percent of Earth's water vapor, giving astronomers a clear window on the infrared universe.

Airborne astronomy took wing in the mid-1960s, when a few pioneering astronomers began to fly high in the stratosphere to study planetary atmospheres and measure the heat given off by the Sun. A Lear Jet with a 12-inch telescope where a passenger window should be was one of the first airborne observatories. It was cramped inside the cabin, and astronomers had to wear bulky, uncomfortable oxygen masks during the flights. "It was rather intimate," Harper remembers. "They had pulled all the seats out. While observing, we sat on the floor."

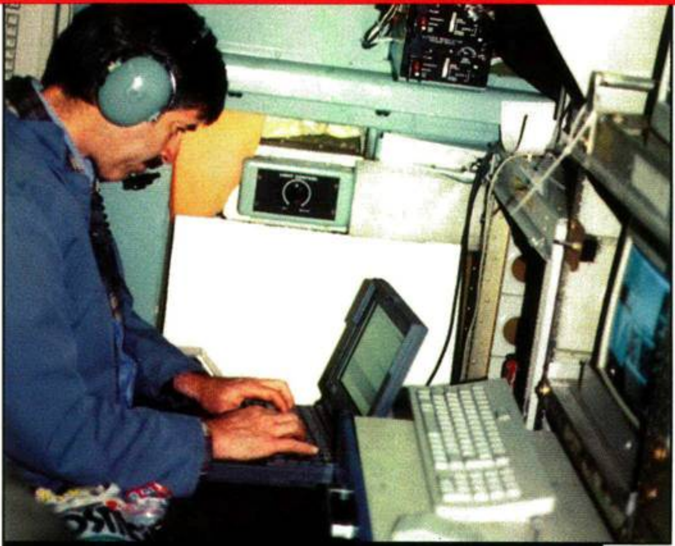
From the Lear Jet, astronomers got their first look behind thick dust clouds in space. The clouds block visible light, but the longer wavelengths of infrared radiation pass through much of the dust unobstructed, revealing newborn stars in their gaseous nurseries, the dying remnants of stellar explosions, and the energetic centers of galaxies.

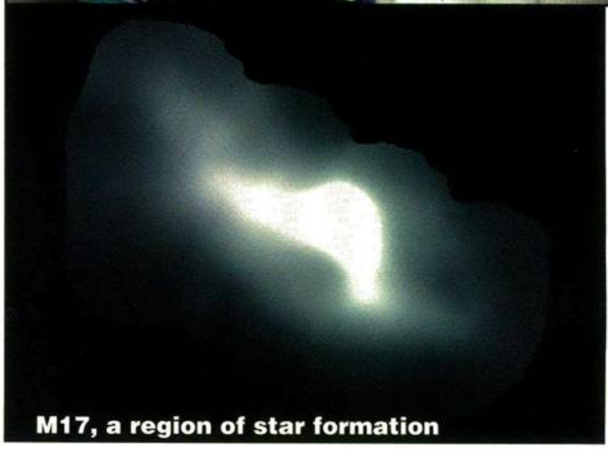
But the Lear Jet carried a small telescope and could

The leader of tonight's observing team, Al Harper (right, in green), sits behind a rack of electronic equipment that controls the infrared camera attached to the telescope four feet away. Joanna Lees, behind Harper, logs the observations during the flight.

Dave Cole (far left) is working on a quick-look picture of the previous region they looked at. Ben Burress is the night's star tracker, keeping the telescope pointed in the right direction.

Keeping the equipment running is the job of Bob Loewenstein.





M17, a region of star formation

Al Harper, Yerkes Obs.

remain aloft for only two and a half hours, half of which was spent climbing to and descending from the stratosphere. Astronomers pushed for a larger, more sophisticated flying telescope and, in 1974, got the KAO, named after Gerard P. Kuiper, a prominent planetary astronomer and a pioneer of airborne astronomy. "The Lear Jet was about the size of a Volkswagen bus," Harper recalls. "The KAO is more like a Greyhound bus . . . it gives you more elbow room."

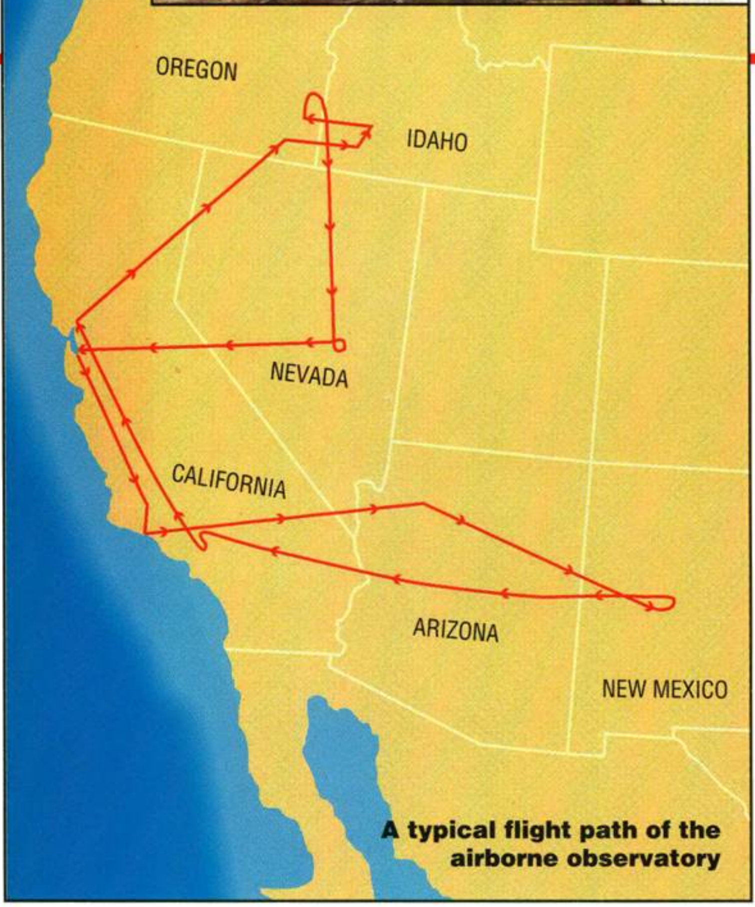
Harper remembers his first flights aboard the KAO. At first, cameras weren't up to the job of guiding the telescope, unable to see stars fainter than fourth magnitude. To guide, Harper sat on a folding stool beside the telescope, his eye close to the eyepiece and a black hood covering his head to block out cabin lights. Air turbulence made the telescope constantly bounce back and forth. "I was always afraid of getting a black eye," Harper says. But engineers improved the guide system, and Harper now guides the telescope from his seat behind the equipment rack.

During the flight, the roar of the engines makes normal conversation impossible. So everyone onboard wears headphones and speaks into microphones. With eleven astronomers and technicians all listening to the same channel, there is no such thing as a private conversation. Indeed, when more than one person is speaking, it gets quite confusing. The cabin is noisy because it has none of the sound insulation found on commercial airliners. It also has no thermal insulation, so most of the astronomers wear heavy sweaters to ward off the chill. The cold is especially noticeable near the metal flooring; drinks left on the floor can freeze.

Clad in a military-green flight suit, Harper doesn't seem to notice the cold. His attention is divided between the monitor used to guide the telescope and a second monitor that displays infrared maps of objects observed earlier in the flight. He leans across the narrow aisle, straining to see details in the map of the star-forming region Sharpless 106 in the constellation Cygnus, created from observations taken only minutes ago. "There's some interesting-looking stuff in there," he says to no one in particular. In the image, areas of intense infrared radiation indicate a ridge of material extending to one side of a very young star. Another ridge can be seen on the other side of the star. These ridges may represent the edges of an area in the nebula swept clear of gas and dust by a high-speed wind that blew from the star earlier in its young life.

Harper and his colleagues are trying to understand star-forming regions in our Milky Way Galaxy and other galaxies. "Our understanding of these regions has increased over time," Harper says. "First we could measure just the total energy radiated by them. Now, we can see structure in the clouds." By making detailed maps of the infrared emission in these giant clouds of dust and gas, the team of astronomers hope to locate hot spots that may signal the presence of young stars

"At 33,000 feet, while still gaining altitude, a door opens, uncovering the 36-inch telescope that looks out a hole in the side of the plane."



A typical flight path of the airborne observatory

embedded deep within the clouds. Light from the embedded stars is completely absorbed by dust in the clouds, rendering them invisible at visual wavelengths. However, the heated dust re-radiates the energy in the far-infrared (wavelengths from about 30 to 200 microns). The researchers want to learn more about the interactions between these young stars and the rest of the cloud material.

Two Decades of Discovery

With over 70 research flights a year, the KAO's regular trips to the stratosphere have produced significant scientific results. Observations in visible light made from the KAO in 1977 as the planet Uranus moved in front of a star revealed for the first time that the blue-green planet has nine narrow rings. Similar observations of Pluto in 1988 showed the tiny planet to be surrounded by a thin atmosphere, probably made of methane. In both cases, the KAO had to be at a specific place on Earth, where the planet, star, and observer lined up exactly at just the right time; no problem for an airplane, but quite impossible for a normal observatory with telescopes anchored in the ground.

In addition, astronomers using the KAO were the first to detect water molecules in comets, supporting the idea that comets are "dirty snowballs." They have shown that stars are forming in Bok globules, coal-black clouds of gas and dust once thought to be devoid of stars, and they have identified molecules in interstellar space, including complex carbon-based materials similar to those from which life on Earth began. Observations made from the KAO detected a ring of dust and cool gas surrounding the dynamic central regions of the Milky Way. And other studies indicated that because of powerful emissions at far-infrared wavelengths, spiral galaxies are twice as luminous as had been thought.

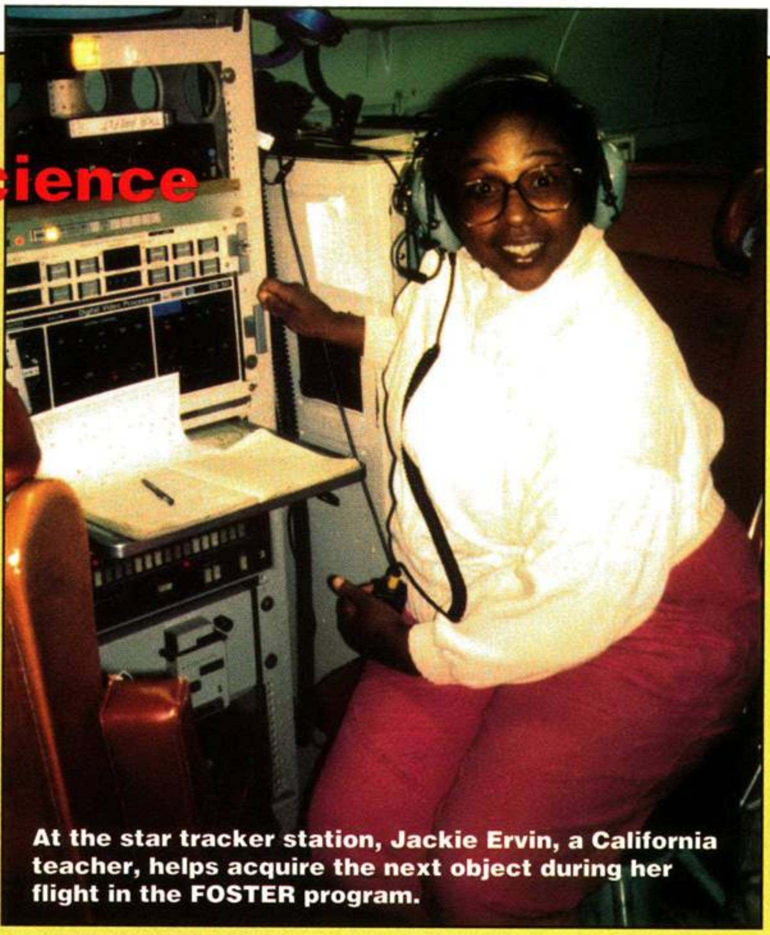
The KAO's legacy of discovery results from the observatory's unique attributes. "It has much more flexibility than Earth-orbiting satellites," Harper says. Should anything go wrong with an instrument, it's easy for technicians to reach and fix it; repairs and modifications can be made during or between flights. And the continual upgrading of instruments that fly on the KAO ensures that astronomers have access to the latest state-of-the-art equipment for their observations.

Perhaps the KAO's greatest asset is its mobility. The airplane spends about two or three months of the year away from the Ames Research Center, flying out of Hawaii, Australia, New Zealand, Chile, and other countries. This makes it the only observatory with access to any part of the sky at any time (it typically takes satellite observatories six months to observe the entire sky). And it can fly to wherever the optimum location is to observe unexpected or unusual events, such as last July's collision of Comet Shoemaker-Levy 9 with the planet Jupiter.

The Next Step

As delighted as they are with the KAO, astronomers are limited by the resolution and light-gathering ability of its telescope. So they have designed a fitting successor, the Stratospheric Observatory for Infrared Astron-

FOSTERing a Love of Science



At the star tracker station, Jackie Ervin, a California teacher, helps acquire the next object during her flight in the FOSTER program.

FOSTER Project, NASA

In March 1993, a pair of pre-college science teachers boarded the *Kuiper* Airborne Observatory for a night's flight with research astronomers. Their flight had been arranged through the FOSTER program (Flight Opportunities for Science Teacher EnRichment). They had already attended a week-long workshop at NASA's Ames Research Center in which they heard lectures about astronomy and the KAO, worked with special hands-on curriculum materials developed for the program, and spent time with astronomers who regularly fly on the KAO. Once airborne, the teachers mingled freely with the astronomers, asked questions, helped take data, and even guided the telescope for a while.

They were the first of 25 teachers who have so far flown on the KAO. Two dozen more get the opportunity each year. "This isn't just a joy ride," says Edna DeVore, the FOSTER program director. "It's more than just an interesting experience. [The program] enhances their sense of what science is about." Indeed, one of the things that seems to make the greatest impression on the teachers is the way astronomers work together as a team, both to acquire data and to solve problems that arise during a flight. "It really changes [the teachers'] view of scientists and doing science," DeVore says.

The teachers take their newfound sense of what it really means to do science, along with great pictures and stories, back to their classrooms. Their enthusiasm can't help but rub off on the students. One high school junior said his astronomy class became "more real" while hearing his teacher describe his night on the KAO. "It sure beats a textbook," added another.

For more information, contact Edna DeVore, FOSTER Project, SETI Institute, 2035 Landings Drive, Mountain View, CA 94043, or Gopher on the Internet to access FOSTER ON-LINE at guest.arc.nasa.gov.

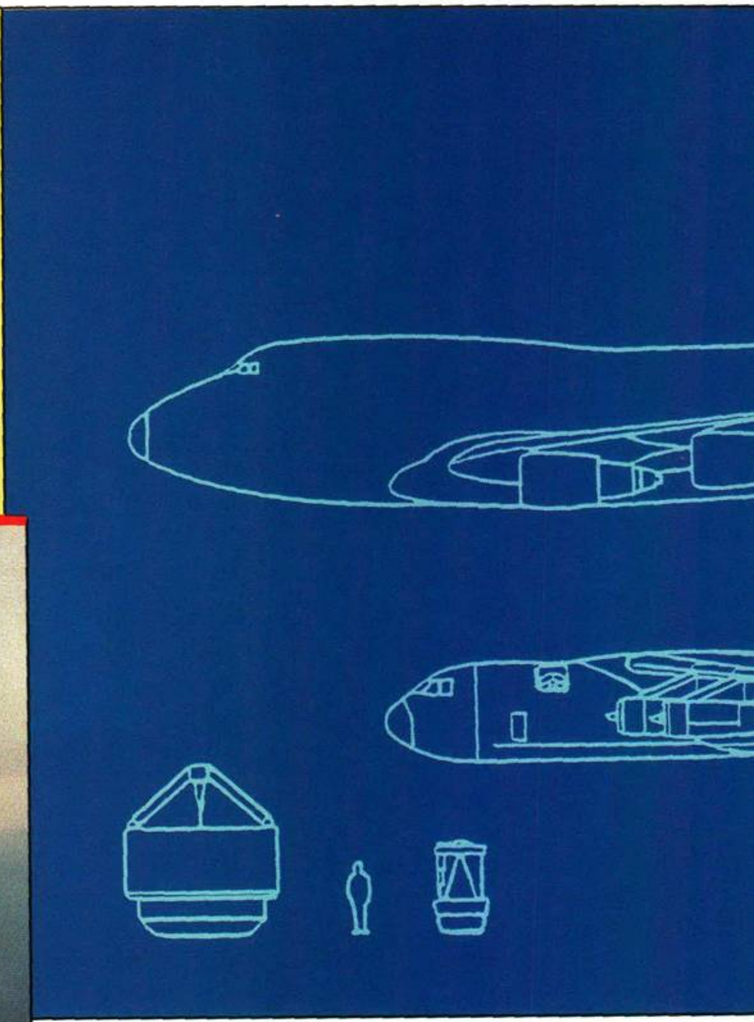
omy (SOFIA), with a 100-inch telescope peeking out of a hole near the tail of a Boeing 747. SOFIA's scope, large even by ground-based standards, will see ten times fainter and its images will be three times sharper than is possible with the KAO. "It will be like going from the Lear Jet to the KAO," Harper says. "While now [in the infrared] we can just see the gross structure of spiral arms in galaxies, with SOFIA we should be able to see Orion-Nebula-type objects in those arms." And it will fly more frequently (160 flights a year) and stay up longer on each flight than the KAO's average of 7 hours.

But the estimated price tag of $180 million (including the cost of the 747) makes SOFIA's construction uncertain as NASA strives to cut costs. To make the project more attractive financially, the German Space Agency (DARA), a partner with NASA in SOFIA, will contribute about 20 percent of the cost, including possibly building the telescope. SOFIA could start flying in the year 2000 and be fully operational the next year if funding begins in fiscal year 1996. To further reduce costs, NASA Headquarters has proposed a dramatic sacrifice — mothball the KAO and save the approximately $12 million a year it costs to keep the old C-141 flying.

If SOFIA gets funded and NASA Headquarters "kills" the KAO in 1996, astronomers wouldn't have regular access to most of the infrared universe for the four or five years until SOFIA is ready to fly. Infrared astronomers would prefer to fly the KAO until 1999, at which point it would be retired and its staff assigned to SOFIA. "I hope they don't shut down the KAO for an extended period of time," Harper says. "A lot of good science could be squeezed out of the KAO in those years. If we don't have a flying system, we'll lose operational preparedness. We'll find a way to live with it, but

Here Comes Sofia

Early airborne astronomers used a 12-inch telescope carried by a Lear Jet (bottom). The Kuiper Airborne Observatory (below) with its 36-inch scope started flying 20 years ago in 1974. To look deeper into the infrared universe astronomers have proposed sending a 100-inch scope aloft in a Boeing 747 (far right). The new airborne observatory is dubbed SOFIA. The new scope, shown at right next to the KAO scope, would have ten times greater sensitivity and three times greater resolution.



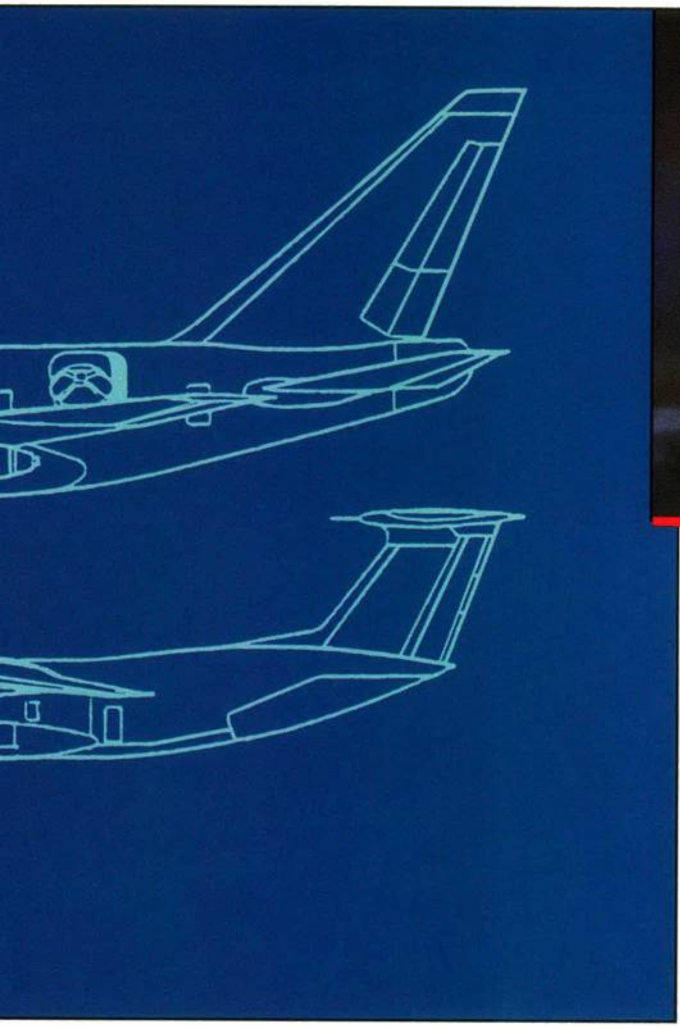
we will lose something in the process. But we have to look to the future."

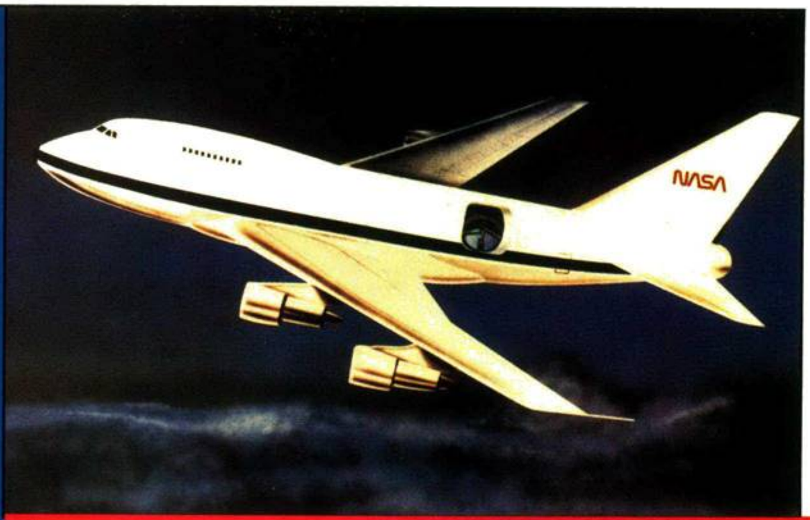
The End of a Good Flight

While politicians, NASA officials, and astronomers debate the future of SOFIA, the KAO continues to fly, exposing new generations of astronomers to the wonders seen from the stratosphere. Harper began flying on the Lear Jet in 1969, when he was in graduate school. Now, when he flies on the KAO, his own graduate students and post-doctoral fellows accompany him. They function as a team, working efficiently to get the most out of their limited time on the telescope. Senior research associate Bob Loewenstein sits two seats from Harper, huddled under a blanket for protection from the cold emanating from the plane's thin skin immediately to his left. He makes sure all the equipment works properly. Post-doctoral researcher Joanna Lees kneels on a seat that backs up against those occupied by Harper and Loewenstein, keeping a log of the observations. She and Harper constantly discuss how the night is going, what they are seeing, and how everything is working. Graduate student Dave Cole works on a computer across the aisle, creating the "first look" maps of objects observed earlier.

To Cole's left is the console of the star tracker, the KAO technician responsible for finding each new object for the telescope. This isn't as easy as it sounds since the infrared sources studied are often invisible on the television monitor used to guide the telescope. To confirm that the telescope is pointed properly, Ben Burress, the night's star tracker, holds up clear plastic sheets on which he has previously marked the position of the target object relative to nearby stars. When the stars' positions match those on the acetate, he knows precisely where the *invisible* source is in the telescope's field of view.

In the meantime, as Harper studies Cole's maps, Lees





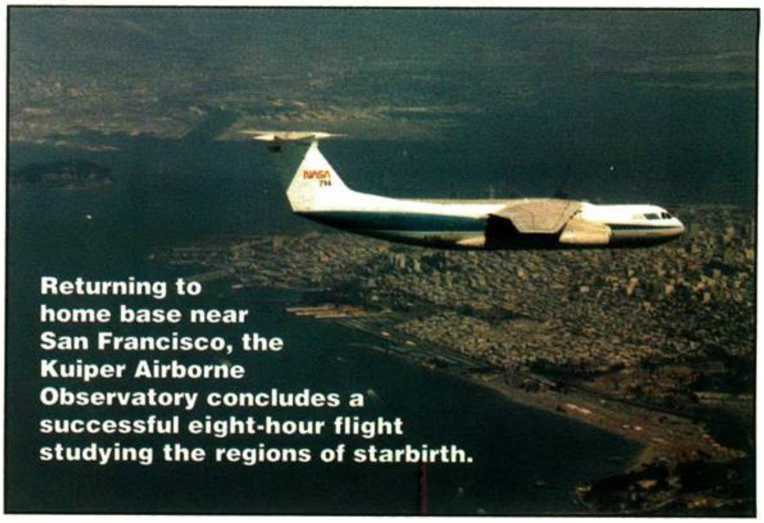
shouts "Cage" into her microphone, signifying the end of another observation. Inside the telescope cavity, a piston moves out and latches onto the telescope, holding it secure while the plane banks sharply to the right. Within a minute or so, the KAO is flying along a new heading, the telescope is then uncaged and locked on yet another star-forming region. The direction the plane heads on each leg of the flight depends on where in the sky the object to be observed is located. The telescope can only point out the left side of the plane, so to look at something in the south the plane has to fly west.

Assembling a continuous flight plan from all possible legs is a formidable challenge. Several days before the flight, Lees sat at a computer in a windowless room known as "The Cave" on the second floor of the KAO's hanger and, largely by trial and error in a kind of "connect-the-dots" game over the entire western United States, came up with a tentative flight plan. The primary constraint on the plane's path is that it has to end up, seven and a half hours later, at NASA Ames, the same place it started. Lees also had to take account of high-altitude winds that can blow the KAO off course and make sure it didn't fly over any of the large patches of restricted airspace that dot the western United States.

Once the flight plan is finalized and filed with the FAA, it is nearly impossible to change. Unlike at earthbound observatories, scientists can't decide to spend more (or less) time observing a galaxy or star that proves to be more (or less) interesting than they expected. "Can we have 30 seconds more?" Lees asks mission director Wendy Whiting, the liaison between the pilots and the astronomers. The additional time will allow them to finish the final map of a star-forming region. Whiting hesitates slightly, then says, "Okay, but no more." Thirty seconds later than originally planned, Lees shouts "Cage," and the plane turns sharply onto a new heading.

Finally, at around 5:30 in the morning, we begin a rapid descent, dropping from 41,000 feet to the ground in just under 15 minutes. Harper and his colleagues are happy with the flight; they have gotten enough good data to keep them busy for months. As the airplane doors open, and the astronomers sleepily file off the plane, members of the ground crew rush in. There are new systems to test, maintenance to perform, and minor problems to fix. For in less than 17 hours, the KAO will once again rumble down the runway, carrying Harper and his colleagues back up to the stars. ☐

Sally Stephens is an astronomer and freelance writer living in San Francisco. From 1992 to 1994 she served as the editor of Mercury *magazine.*



Returning to home base near San Francisco, the Kuiper Airborne Observatory concludes a successful eight-hour flight studying the regions of starbirth.

SKY ALMANAC

November 1994

Total Eclipse Over South America

One of the best eclipses since the July 1991 total eclipse washes over central South America on November 3. Areas in the path include the Peruvian coast, south-central Bolivia, southern Paraguay, and southern Brazil. The eclipse will last as long as 4 minutes and 23 seconds.

Earth's Shadow Brushes the Moon

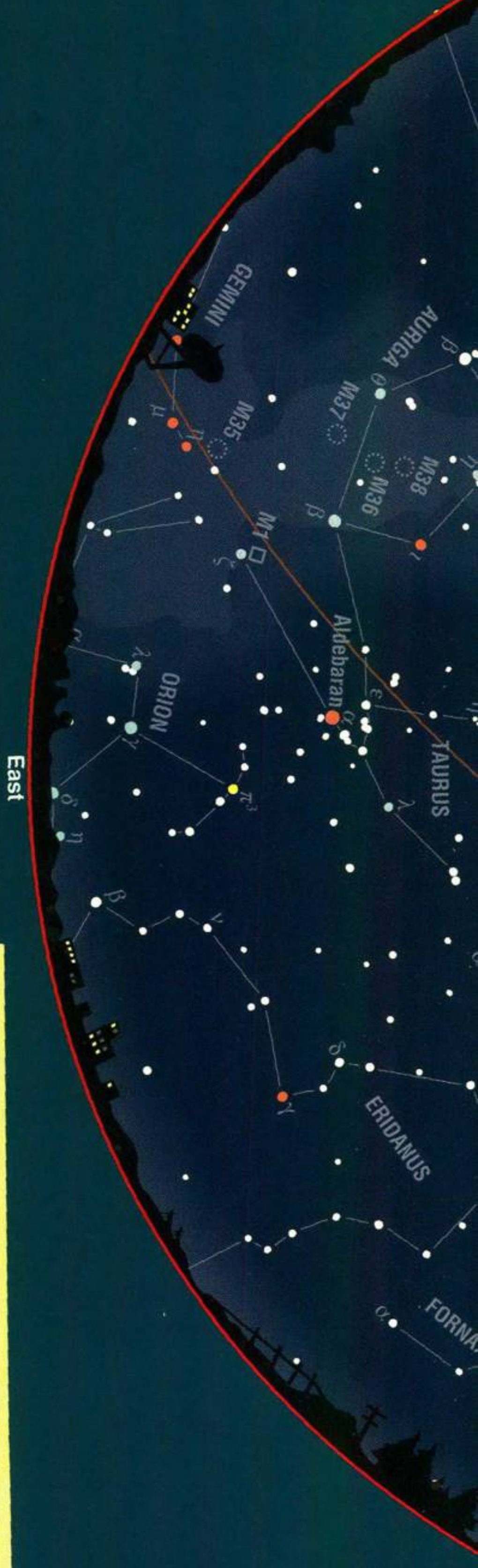
North American observers will see a penumbral eclipse of the Moon on November 17/18. High in the sky at mid-eclipse, the Moon will be 91 percent covered by shadow. This eclipse may be particularly dark as penumbral events go.

Mercury is High in the Morning Sky

A grand opportunity to spy elusive Mercury comes in the first half of this month, when the speedy planet is a visitor to the morning sky. At a maximum altitude of 60° above the horizon on November 6, Mercury will be easy prey for observers equipped with binoculars.

Asteroid 40 Harmonia Meets the Hyades

The Hyades and Pleiades star clusters, prominent locants in the winter evening sky, host a tiny asteroid this month. Tenth-magnitude 40 Harmonia will skirt the Hyades cluster, making it relatively easy to pick out against the familiar background of stars.



CALENDAR OF EVENTS

2 Venus is at superior conjunction, 6 p.m. EST

3 Southern Taurid meteor shower peaks, 2 a.m. EST
New Moon is at 8:35 a.m. EST; total eclipse
The Moon is at perigee (221,978 miles from Earth), 7 p.m. EST

5 Mercury is at greatest western elongation (19°), 8 p.m. EST
Vesta is stationary, 10 a.m. EST

8 Pallas is at opposition, 3 p.m. EST

9 Saturn is stationary, 4 p.m. EST

10 First Quarter Moon is at 1:14 a.m. EST

12 Venus passes 5° south of Mercury, 1 p.m. EST

13 Northern Taurid meteor shower peaks, 1 a.m. EST

17 Jupiter is in conjunction with the Sun, 3 p.m. EST
Leonid meteor shower peaks, 4 p.m. EST

18 The Moon is at apogee (252,491 miles from Earth), midnight EST
Full Moon is at 1:57 a.m. EST, penumbral eclipse
Juno is in conjunction with the Sun, noon EST

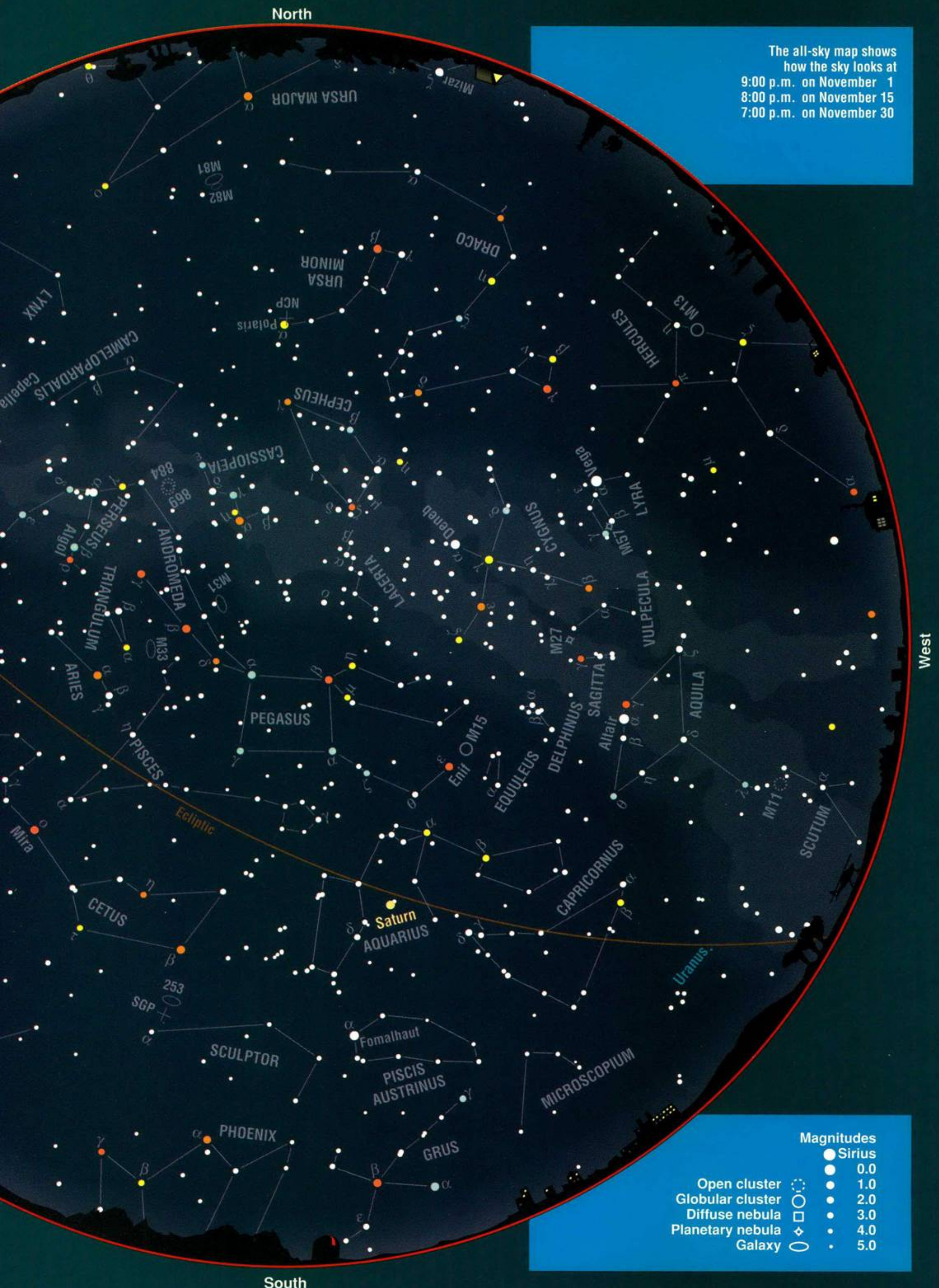
20 Pluto is in conjunction with the Sun, 8 a.m. EST

21 The Moon passes 1° south of Vesta, 7 p.m. EST

26 Last Quarter Moon is at 2:04 a.m. EST

30 The Moon passes 2° south of Venus, 9 a.m. EST

The all-sky map shows
how the sky looks at
9:00 p.m. on November 1
8:00 p.m. on November 15
7:00 p.m. on November 30


North
URSA MAJOR
Mizar
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
HERCULES
M13
CEPHEUS
CASSIOPEIA
884
869
PERSEUS
Algol
Vega
LYRA
M57
Deneb
CYGNUS
LACERTA
ANDROMEDA
M31
TRIANGULUM
M33
ARIES
VULPECULA
M27
SAGITTA
West
AQUILA
Altair
DELPHINUS
PEGASUS
M15
Enif
EQUULEUS
PISCES
Ecliptic
M11
SCUTUM
Mira
CETUS
CAPRICORNUS
Saturn
AQUARIUS
Uranus
253
SGP
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

SKY ALMANAC

by Deborah Byrd and Jeff Kanipe

Insubstantial shadows create two of this month's most fascinating sky events. The first occurs on November 3, when the Moon passes directly in front of the Sun. On this day, the Moon's shadow touches down on Earth and sweeps across a portion of the Southern Hemisphere, creating the only total solar eclipse between June 1992 and October 1995.

The total eclipse is visible along a path that cuts across Peru, Chile, Bolivia, Paraguay, Argentina, and Brazil. The duration of totality near the centerline ranges from less than three minutes in Peru to four minutes on the coast of Brazil. It will be a memorable few minutes for those whose skies are clear on eclipse day.

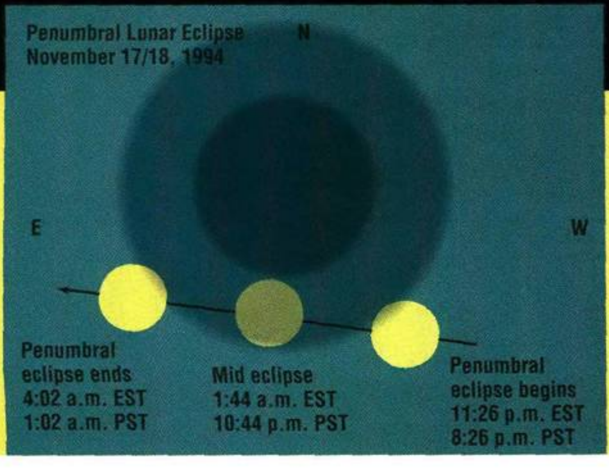
People throughout the rest of South America and much of Central America, southern Africa, and Antarctica see a partial eclipse of the Sun on November 3. Those in the *penumbral shadow* see a partial eclipse. Those in the dark umbral shadow see a total eclipse. For more details on the eclipse, see "Reaching for the Corona" by Joel Harris, page 82.)

Like the Moon, Earth also casts a shadow. Extending nearly a million miles into space, Earth's shadow also consists of a dark inner umbra and lighter surrounding penumbra. The most distant Full Moon of the year wanders into the penumbral shadow of Earth on the night of November 17/18. A deep *penumbral lunar eclipse* occurs, visible to all in the Americas. At mid-eclipse, a dusky shade — Earth's penumbral shadow — covers 91 percent of the Moon. This happens at 1:44 a.m. EST on November 18 (10:44 p.m. PST on November 17). Penumbral eclipses are always subtle, but this should be a particularly dark one, noticeable to observant watchers of the skies. Binoculars or a telescope will enhance the view.

In early November, watch for two brightly shining objects in the eastern predawn sky. Mercury and Spica are noticeable for being close together in the sky and for their brightness before the coming dawn. Mercury is the object on the left. Autumn mornings always bring its best predawn apparition of the year. The other object is the bright star Spica in the constellation Virgo. Be sure to look for Mercury and Spica 45 minutes to half an hour before sunrise. Mercury's greatest elongation, when it appears farthest from the Sun in our sky, comes on November 5.

Afterward, Spica appears noticeably higher each day in the predawn sky, while Mercury lingers near the eastern

H. C. Ng



The Moon in Penumbral Eclipse

The Moon edges into the outer fringes of Earth's shadow on November 18, creating the last of the lunar eclipse events for the year. This penumbral eclipse will be widely seen across North America, where the Moon will be high in the sky at mid-eclipse.

The shadow show begins at 11:26 p.m. EST, but because the Moon will just be entering the penumbra, little shading will be seen until about an hour later. Mideclipse occurs at 1:44 a.m EST. At that time, the northern limb of the Moon, the edge nearest the umbra (but not in contact with it for this eclipse) will be noticeably darker than the southern limb. The Moon is in Taurus, and the Pleiades cluster lies only 7° to the north.

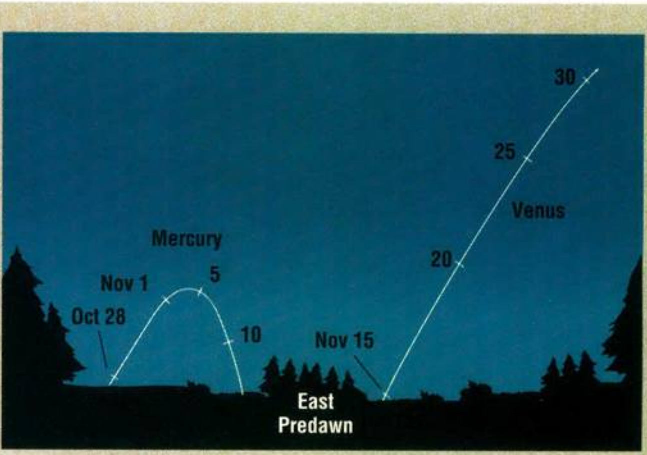
The last vestiges of the eclipse end a couple of minutes after 4 a.m. EST, although by then, only die-hard Moon watchers will still be watching

Mercury in the Morning Sky

If you've never seen the planet Mercury, now's your chance as the planet reaches greatest elongation — it's greatest angular distance — west of the Sun in the morning sky. Greatest elongation occurs on November 5, which means the planet will be optimally placed for observers in the Northern Hemisphere for the first half of the month.

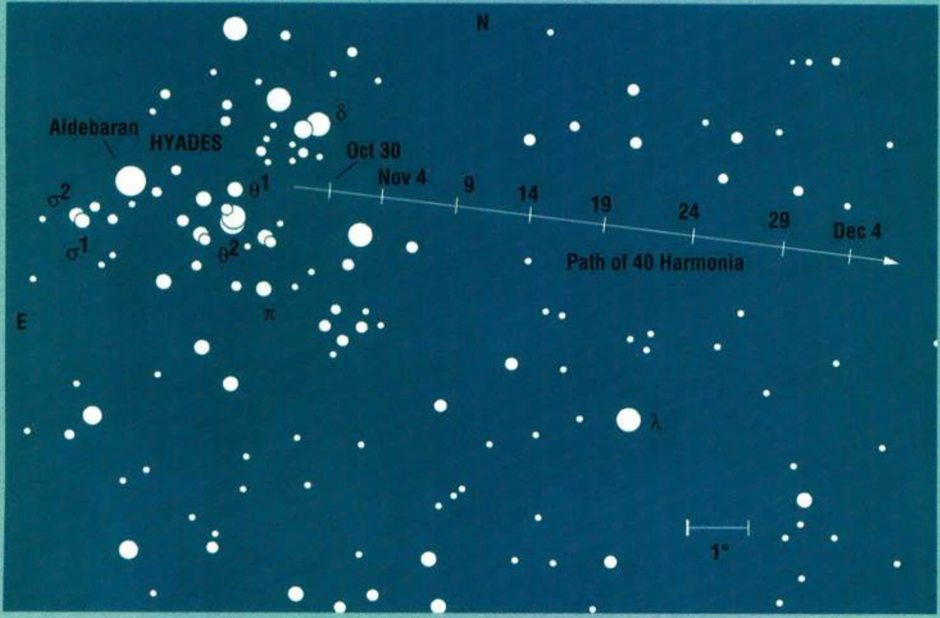
On the first, Mercury exhibits a slightly crescent-shaped disk in telescopes and is still climbing above the eastern horizon. It is well placed on the 6th, when it reaches an altitude of about 6°.

One of the best ways to locate Mercury in the brightening morning twilight (since it never strays far from the Sun, one never sees it in a completely dark sky) is to rise about an hour and a half or two hours before the Sun and select an observing site where your east-southeast horizon is flat and unobstructed. Scan the sky with binoculars, looking for a dull red "star." Brilliant Venus makes it easy for you to spot Mercury this month, for it drifts near the planet around mid-November. On the 12th, in fact, Mercury lies 5° north of Venus.



Meanwhile, don't confuse Arcturus with Mercury, which lies more to the northeast, or Spica, which is whiter in color and not quite as bright. At the beginning of the month, Mercury's magnitude is 0.1, but by month's end jumps to −0.8. With the favorable geometry and Venus' help, you should be able to track Mercury throughout November and perhaps even into the first days of December.

Asteroid 40 Harmonia Visits the Hyades



Around 9 p.m., the Hyades and the Pleiades star groups are well up in the eastern sky. Shifting between these asterisms throughout the month is the 70-mile-diameter minor planet 40 Harmonia. This object reaches opposition November 23, when it peaks in brightness at magnitude 9.5. Given the rich area of sky (on the fringes of the winter Milky Way), identifying 40 Harmonia may be a challenge for first-time asteroid observers.

Use the finder chart to help you narrow the search field for the evening you will be observing. Try an eyepiece that produces no more than 1° of sky. If your field of view is too big you will lose the asteroid among the stars and its motion won't be apparent. If, on the other hand, your field is too small you may waste time looking too closely in the wrong place.

Center the field of view on the region and carefully sketch all the stars you see. Come back a few hours or even a night or two later and compare your sketch with the view in the eyepiece. The "star" that has moved is 40 Harmonia.

ASTEROID 40 HARMONIA POSITIONS

Date	**R.A. (2000)**	**Dec.**	**Mag.**
Oct. 30	4h21.6m	16°39'	10.0
Nov. 4	4h17.7m	16°32'	9.9
Nov. 9	4h13.1m	16°26'	9.8
Nov. 14	4h8.0m	16°19'	9.7
Nov. 19	4h2.6m	16°12'	9.5
Nov. 24	3h57.0m	16°6'	9.5
Nov. 29	3h51.5m	16°1'	9.6
Dec. 4	3h46.1m	15°57'	9.7

The Satellite Galaxies of M31

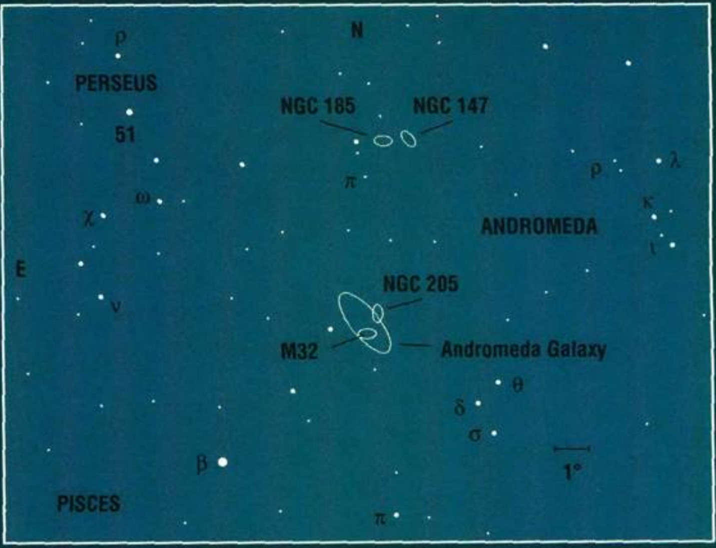
Near the zenith as darkness falls this time of year is a familiar oval glow that one can just glimpse with the naked eye from a dark sky site out in the country: the Andromeda Galaxy, M31. Through a telescope at low power, this object spreads out into a milky glow with a bright, knotted nucleus and tenuous outer disk crossed with a narrow lane of dark dust. Many first-time observers of M31, while impressed with the galaxy's magnificent presence in the eyepiece, miss four satellite galaxies, two of which can be seen in the same field of view as M31 if the magnification is low enough.

Easiest to spot is M32, which lies just southeast of the nucleus along the outer periphery of the visible disk of M31. This object, like all of M31's companions, is a dwarf elliptical galaxy. At magnitude 9.5, M32 is fainter than M31 (magnitude 3.5), but it appears as bright as a piece of the nucleus of the great galaxy because it is much smaller and its light more concentrated on the sky. Some people, in fact, mistake M32 for a star, until they look at it closely and notice that it has fuzzy edges.

About 1° northwest of the nucleus, and perpendicular to the long axis of the Andromeda Galaxy, lies a broad oval patch of light that is not quite as bright as M32, because it is larger and thus more spread out. This is NGC 205, sometimes called M110 (although Messier did not log it in his catalog). It is the largest of the companions to M31. NGC 205 is elongated, smooth, and bright over its entire surface, except at the edges, where the light suddenly falls off. If your field of view is less than a degree, you will need to nudge your telescope slightly away from M31 in order to see NGC 205.

To see M31's other companions, you will need to shift your field of view some 7° north and slightly west. Lying on an east-to-west line are NGC 185 and 147. The easternmost, NGC 185, is the brighter of the two (magnitude 11.8) with a distinct oval-like shape similar to that of NGC 205. NGC 185 is also smaller than its next-door neighbor, NGC 147 and, once again, we see that a smaller angular size — in extended objects anyway — often translates into greater surface brightness because its light is more concentrated. NGC 147, 1° to the west, has an apparent magnitude of about 12. Both of these galaxies can be seen in an 8-inch telescope from a dark sky location, but NGC 147 is the more challenging of the two.

All four galaxies contain millions of stars and lie at close to the same distance as M31, 2.2 million light-years.



M32 Paul Roques

NGC205 Kim Zussman

NGC147 Harvey Freed

NGC185 Harvey Freed

horizon. Then another planet — the brightest of them all — ascends over that horizon. Venus goes between Earth and the Sun on November 2. Look for it beginning around November 8, when it rises in the east-southeast within 12 degrees of Mercury. On November 14, Venus and Mercury — like two oxen in a yoke — come up at the same time and appear side by side in the dawn twilight.

Mercury sinks again into the Sun's glare after mid-month, while Venus appears higher in the predawn sky each day. Look for the planet on the morning of November 30, when it is near the waning crescent Moon. On that day, Jupiter is rising in the east-southeast, 25° to the lower left of Venus.

Binocular and telescopic observers can catch sight of Comet Borrelly at its brightest for the year in mid-November at magnitude 8.0. This comet will be nearest to us in early December and reach opposition to the Sun in February 1995.

This month's asteroid has the lovely name of 40 Harmonia. Its opposition comes on November 23, when it will shine at magnitude 9.5.

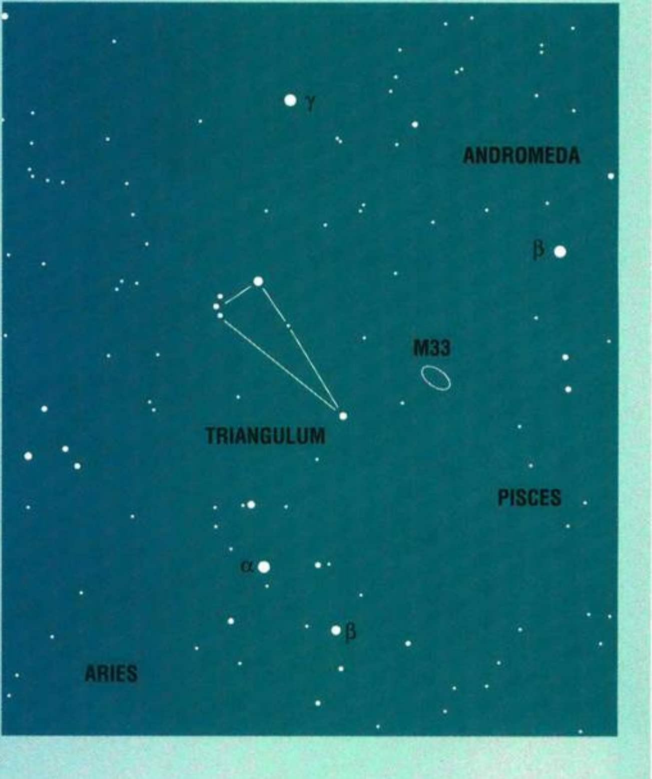
Observers with very dark, moonless skies this month should gaze toward the closest large spiral galaxy — sometimes said to be the only galaxy visible to the eye from the Northern Hemisphere — M31 in the constellation Andromeda. It's more than two million light-years away and harbors a cloud of faint satellite galaxies. For more on another, more difficult naked-eye galaxy visible from this hemisphere, see "The Starry Sky" at right.

November's Planets

Jupiter is in the evening sky when this month begins, but it sets so soon after sunset that you probably won't see it. The giant planet is in conjunction with the Sun — behind the Sun from Earth — on November 17. By the month's end, it may be visible in the morning as a bright light coming over the eastern horizon shortly before the Sun.

THE STARRY SKY

by Deborah Byrd



Triangulum, the Triangle is one of the sky's overlooked constellations. It's small and faint, and yet it contains an object so compelling that it could cause you to return again and again to this region of the heavens. Triangulum appears as a small triangle. It arcs overhead on autumn evenings, between the right foot of Andromeda the Princess and the crooked line of stars we see as Aries, the Ram.

The three main stars of Triangulum are faint, but they are visible to those standing under dark skies. They are Alpha, Beta and Gamma Trianguli. Alpha shines magnitude 3.4 across a distance of 64 light-years. This is one case where Alpha is not the brightest star in its constellation. Instead, the brightest star in Triangulum is Beta, with a magnitude of 3.0 and a distance of 110 light-years.

According to some writers, Triangulum represents the island of Sicily, which was said to be honored by Zeus, king of the gods, with a place among the stars. One of the early names for Triangulum was Sicilia. This constellation has also been associated with Egypt and the Nile River. It is sometimes called "the Home of the Nile." Triangulum has a place in this history of astronomy. The first asteroid, Ceres, was discovered within its boundaries by Giuseppe Piazzi on January 1, 1801.

Many observers believe that the Andromeda Galaxy (M31) is the only galaxy visible to the naked eye from the Northern Hemisphere, but there is a galaxy in Triangulum that some observers have also seen with the naked eye. The famous amateur astronomers Walter Scott Houston and Leslie Peltier both wrote of their experiences in glimpsing this galaxy, called M33, without optical aid from very dark sites. While standing under the exceedingly dark clear skies of West Texas — using averted vision — I believe I have glimpsed a ghostly patch where M33 should be.

M33 is sometimes called the Pinwheel Galaxy. It's a nearby spiral galaxy, a member of our Local Group. The galaxy lies in western Triangulum, 14° southeast of M31. It is not much farther away from us than the Andromeda Galaxy, about 2.3 million light-years in contrast to 2.2 million light-years for M31. The difference is that M33 is inherently dimmer and is oriented nearly face-on to Earth and thus its surface brightness is much lower than that of M31. As Leslie Peltier points out in his classic book *Guideposts to the Stars*, "From our direction we have a perfect 'bird's-eye' view of M33. If we could see it from an oblique angle, as we do in the case of M31 in Andromeda, M33 would appear much brighter and would be easily visible to the naked eye."

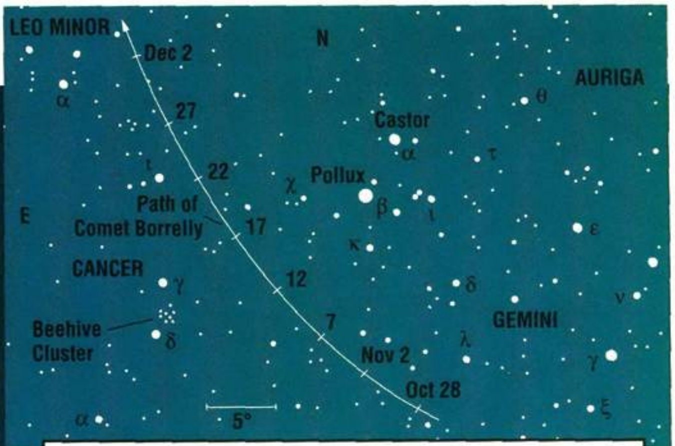
Try to glimpse this elusive galaxy on an exceptionally clear, moonless night. It appears as not much more than a large patch of hazy light. For best results, try using averted vision. In other words, don't stare directly at where you think the galaxy should be. Instead, search for the galaxy out of the corner of your eye. If you see it, you'll keep the memory of the sight tucked in a corner of your heart forever.

Following Comet Borrelly

Last month Comet Borrelly was traipsing through northern Canis Minor and Gemini and glowing at about magnitude 8.2 or 8.3 — making it one of the year's most prominent periodic comets. This month the comet brightens to magnitude 8.0. Borrelly is expected to outperform Comet Encke by virtue of its brightness and favorable viewing geometry: Borrelly, unlike Encke, does not lie between us and the Sun at peak brightness but outside Earth's orbit, so it appears more fully lit.

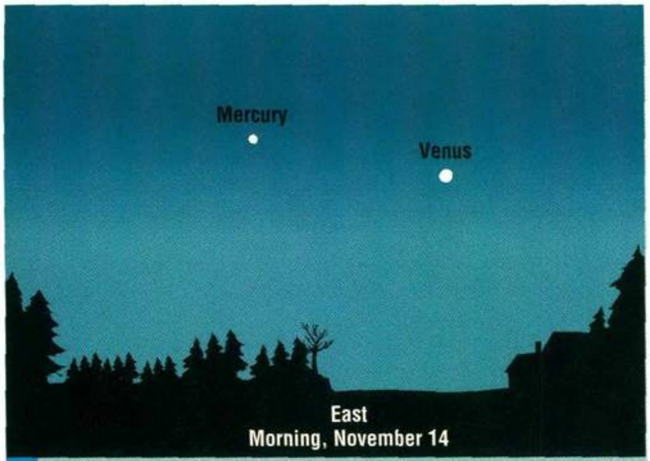
As November begins, Borrelly is moving out of Cancer and into northern Leo. This region, although not rich in stars, does contain numerous galaxies, many of which look like comets, especially elliptical galaxies with bright, starlike nuclei. Don't be fooled. Look for the coma or evidence of a tail. Moreover, as that old French comet hunter Charles Messier used to do, look for the comet's movement against the background of stars. A half hour's observing time should do it, and you will definitely notice movement within an hour's time. This part of the sky rises around midnight, so it is well placed for viewing into the wee hours.

Being an extended object and having its light spread out over its apparent diameter, Borrelly will appear somewhat fainter than its visual magnitude implies. Hence, although its magnitude may be around 8, remember that this is an integrated magnitude, or how bright the comet would be if it were a point source like a star. Look instead for an object with a somewhat lower surface brightness.



COORDINATES FOR COMET BORRELLY

Date	R.A. (2000)	Dec.	Mag.
Oct. 28	7h29.5m	12°25'	8.2
Nov. 2	7h42.6m	15°18'	8.2
Nov. 7	7h55.6m	18°27'	8.1
Nov. 12	8h8.6m	21°51'	8.1
Nov. 17	8h21.5m	25°30'	8.0
Nov. 22	8h34.2m	29°21'	8.0
Nov. 27	8h46.5m	33°21'	8.1
Dec. 2	8h58.5m	37°27'	8.1

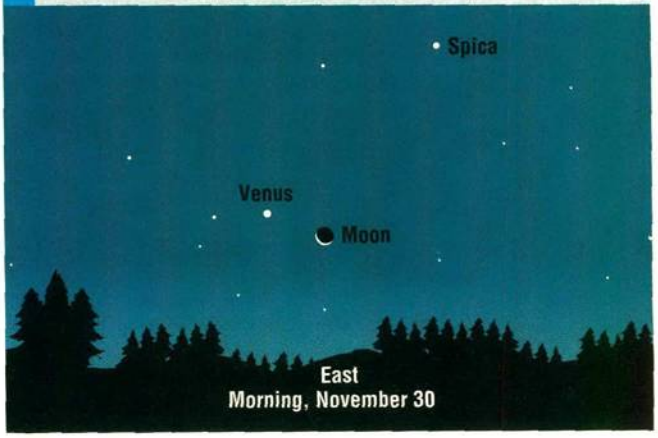


Mercury and Venus Rise Together

Mercury has a favorable elongation for observers in the Northern Hemisphere this month. Nevertheless, Mercury can still be a challenge to locate. You can increase your chances, however, an hour or so before sunrise on November 14. Go out with your binoculars and check out the eastern horizon that morning. You'll easily pick out Venus, very low in the sky but shining bright enough to be seen with the unaided eye. Scan to the north with your binoculars and look for a yellowish "star." If you see it, congratulations — you've found Mercury. These two planets rise together and will be near each other on subsequent mornings. It's not often that we see Mercury higher in the sky than Venus.

The Moon Slips Past Venus

Early risers retrieving their morning paper or getting the trash out will no doubt notice a waning crescent Moon just south of the bright "morning star," Venus, in the twilit dawn sky on November 30. The Moon has been flirting with Venus all year, first in the evening sky, where it skimmed about a degree from the planet last April and now in the predawn sky. It edges past Venus again next month, this time at a distance of 3°. Then, in January, the Moon makes another very close pass — 0.2° to the north — creating an occultation, in fact, for observers in southern Mexico.



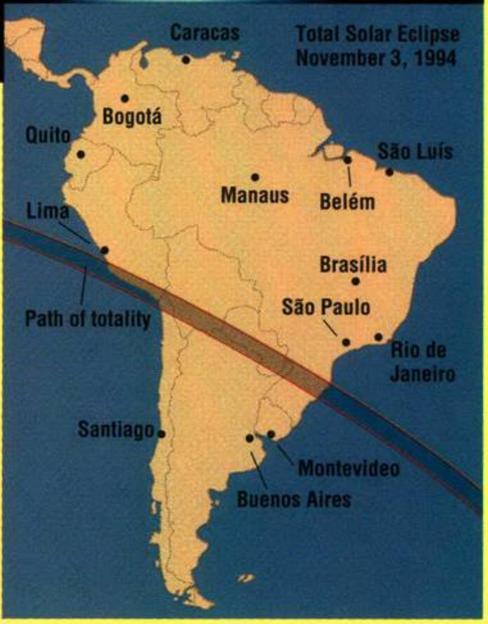
A South American Total Solar Eclipse

On November 3 the last solar eclipse of the year promises to be one of the best since the great eclipse of July 11, 1991. Although the duration of totality at maximum eclipse is more than two minutes less than that of the July 1991 eclipse, totality is totality, even if it lasts just a few minutes. Moreover, this eclipse is not too remotely placed for eclipse chasers in North America, and many are willing to shell out big bucks to make their way to South America or the southern Atlantic by plane, train, or boat to see one of the last good eclipses of the twentieth century. (The one in that part of the world in 1998 should be equally good if not more spectacular.) Totality stretches along a path that begins in the southeastern Pacific Ocean, crosses western South America, traveling from the coast of Peru, through southern Bolivia, Paraguay, and the southern handle of Brazil, then crosses the Atlantic Ocean, where it terminates off the southern coast of Africa.

Some of the best locations include the higher altitudes east of the Peruvian coast and south of the city of Arequipa (where the eclipse occurs just after sunrise), southern Brazil, and the mid-Atlantic Ocean via cruise ship or jet plane. The duration of totality along the Peruvian coast is about 2 minutes 30 seconds. South-central Bolivia sees fully 3 minutes of totality; southern Paraguay averages about 3 minutes 30 seconds. In southern Brazil, the town of Chapecó will experience nearly 4 minutes of totality. Maximum duration in the mid-Atlantic is 4 minutes 23 seconds.

During totality, be sure to take a few seconds to look for Venus just southwest of the Sun, Jupiter to the southeast, and Mercury to the northwest (Spica will be just south of Mercury). Arcturus may be visible 35° or so due north of the eclipsed Sun, as well as Antares 15° to the southeast. And because observers will be so far south of the equator, Alpha and Beta Centauri will also be well placed, about 35° south of the Sun. The further east you are, of course, the higher these objects will be above the eastern horizon.

Jacques Guertin



In the constellation Sagittarius, the Archer, distant **Uranus** and **Neptune** are low in the southwest when night falls. They set several hours behind the Sun. Neptune fades this month to magnitude 8.0, while Uranus shines at magnitude 5.8.

Saturn has faded to magnitude 0.8 in early November, but it's still prominent in a star-poor region of the sky. You'll find Saturn low in the south when night begins, in front of the constellation Aquarius, the Water Carrier. The bright star nearby is Fomalhaut in the constellation Piscis Austrinus, the Southern Fish. Saturn is stationary on November 9. It is near the Moon on the night of November 11.

Telescopically, Saturn is now a 17.5"-diameter golden ball, surrounded by narrow rings. Its rings will continue to appear more edgewise from our Earthly vantage point in the months to come, but this month they appear most open to us for 1994. Guy Ottewell, in this year's *Astronomical Calendar*, has noted something wonderful: That is, the measure of how we see Saturn's rings is the "Saturnicentric latitude of the Earth." In other words, it is the angle at which a being on Saturn would look toward our world, above or below the rings.

Up before midnight in early November, **Mars** can be found in the south an hour before sunup. Mars, now in Leo, spends this month edging toward Leo's brightest star, Regulus. It'll pass within 2° of this star in December and remain near it for many months. Look for Mars, Regulus, and the Moon in a triangle on the morning of November 25.

Mars is near opposition, when we on Earth will pass between this planet and the Sun. That will happen in February. The distance between us and Mars is now decreasing, and Mars brightens from 0.7 to 0.3 magnitude this month. The ruddy Martian disk measures around 8" across now, and you should be able to see the north polar cap. Finally, notice that Mars is not completely round. Instead, it appears about 90 percent illuminated.

Mercury was in inferior conjunction — between Earth and the Sun — last month, and when this month begins it's back in the predawn sky. Its greatest elongation — or greatest apparent distance from the Sun in the sky — comes on November 5. Look for Mercury within 30 to 45 minutes before sunup. It disappears after midmonth.

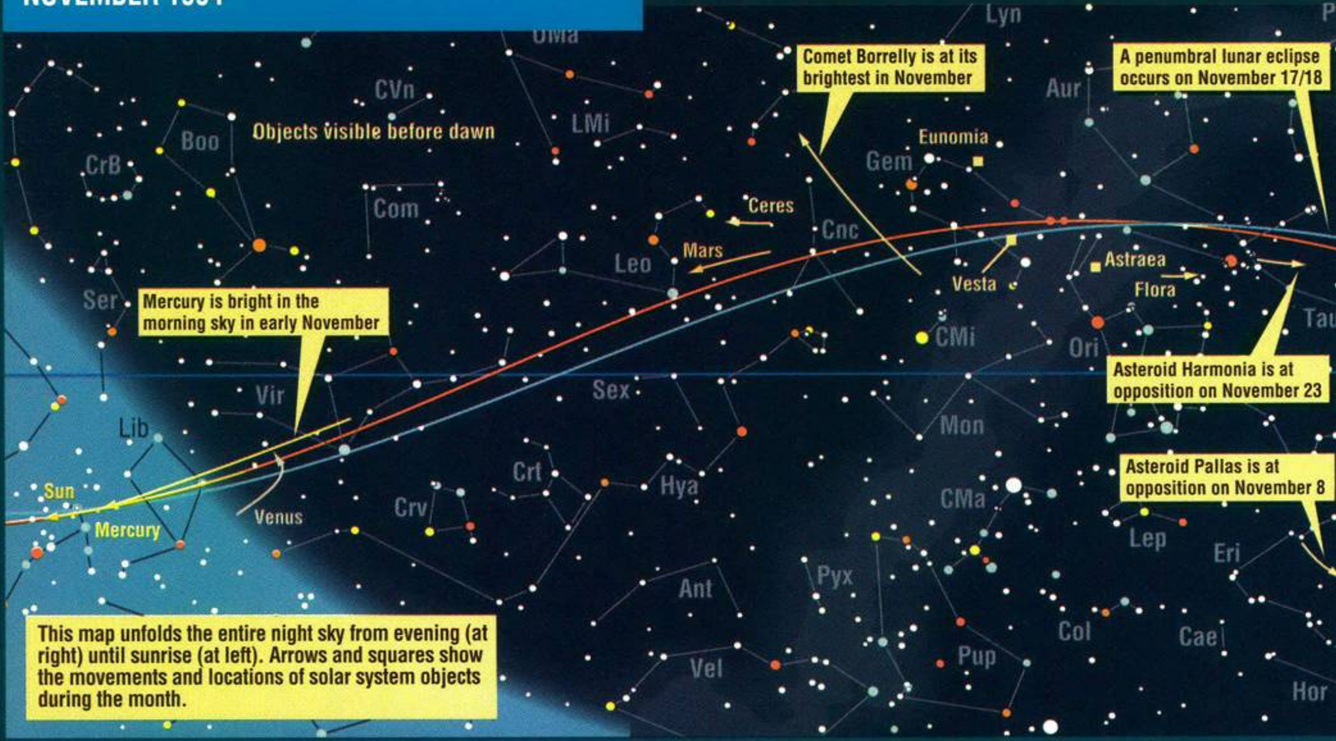
Earth's sister planet **Venus** is at inferior conjunction on November 2. Afterward, it springs into the predawn sky. Venus and Mercury rise together on November 14, and after some time Venus appears higher in the sky. Venus is exceedingly brilliant at magnitude –4.3 and will reach greatest brilliancy in December.

Pluto is in conjunction with the Sun on November 20. Next month, it'll return to the sky before dawn. ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Jeff Kanipe edits Star Date, the University of Texas-McDonald Observatory magazine of astronomy.

SKY ALMANAC

NOVEMBER 1994


Objects visible before dawn
UMa
CVn
LMi
Lyn
Boo
CrB
Com
Ser
Leo
Mars
Ceres
Cnc
Gem
Eunomia
Aur
Vesta
Astraea
Flora
Tau
CMi
Ori
Sex
Vir
Lib
Sun
Mercury
Venus
Crt
Crv
Hya
Mon
CMa
Lep
Eri
Ant
Pyx
Col
Cae
Vel
Pup
Hor

Comet Borrelly is at its brightest in November

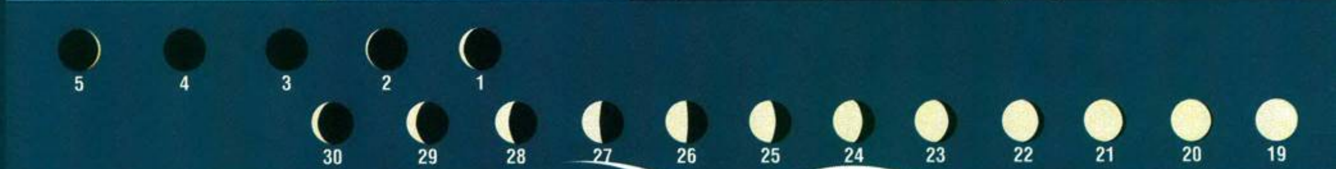
A penumbral lunar eclipse occurs on November 17/18

Mercury is bright in the morning sky in early November

Asteroid Harmonia is at opposition on November 23

Asteroid Pallas is at opposition on November 8

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.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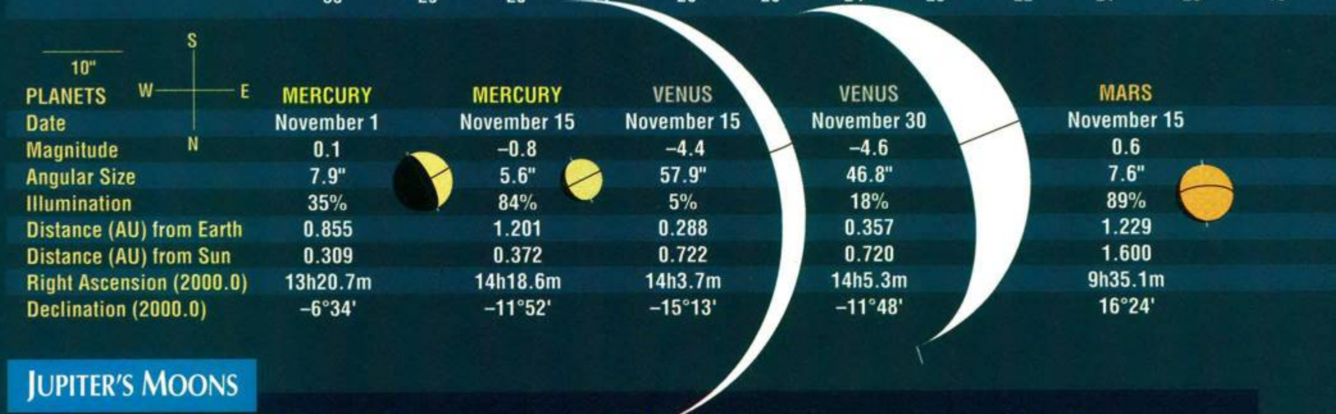
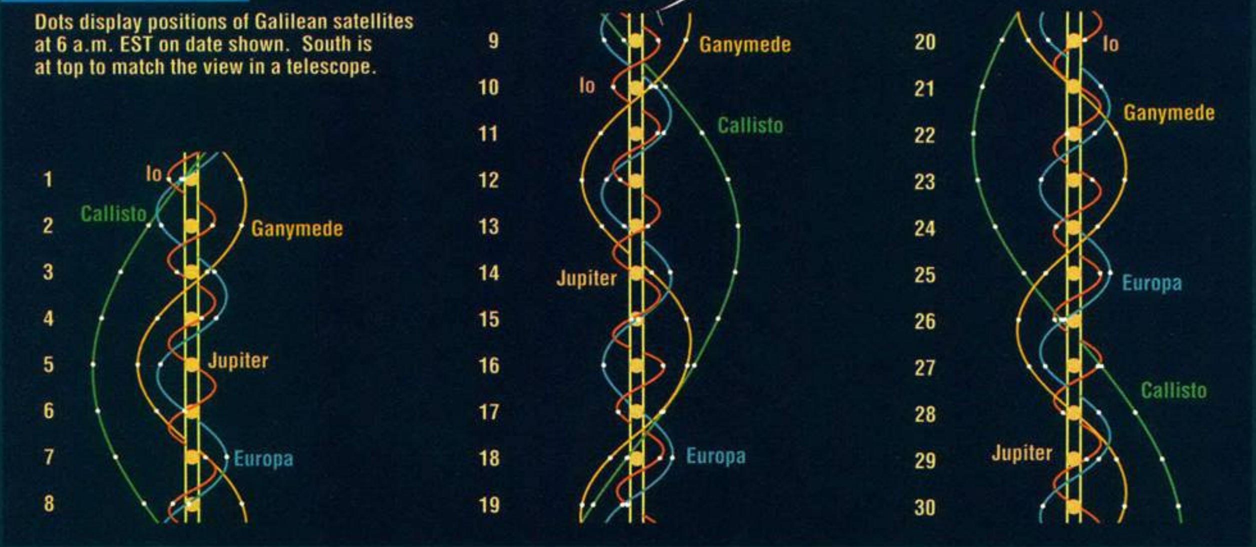
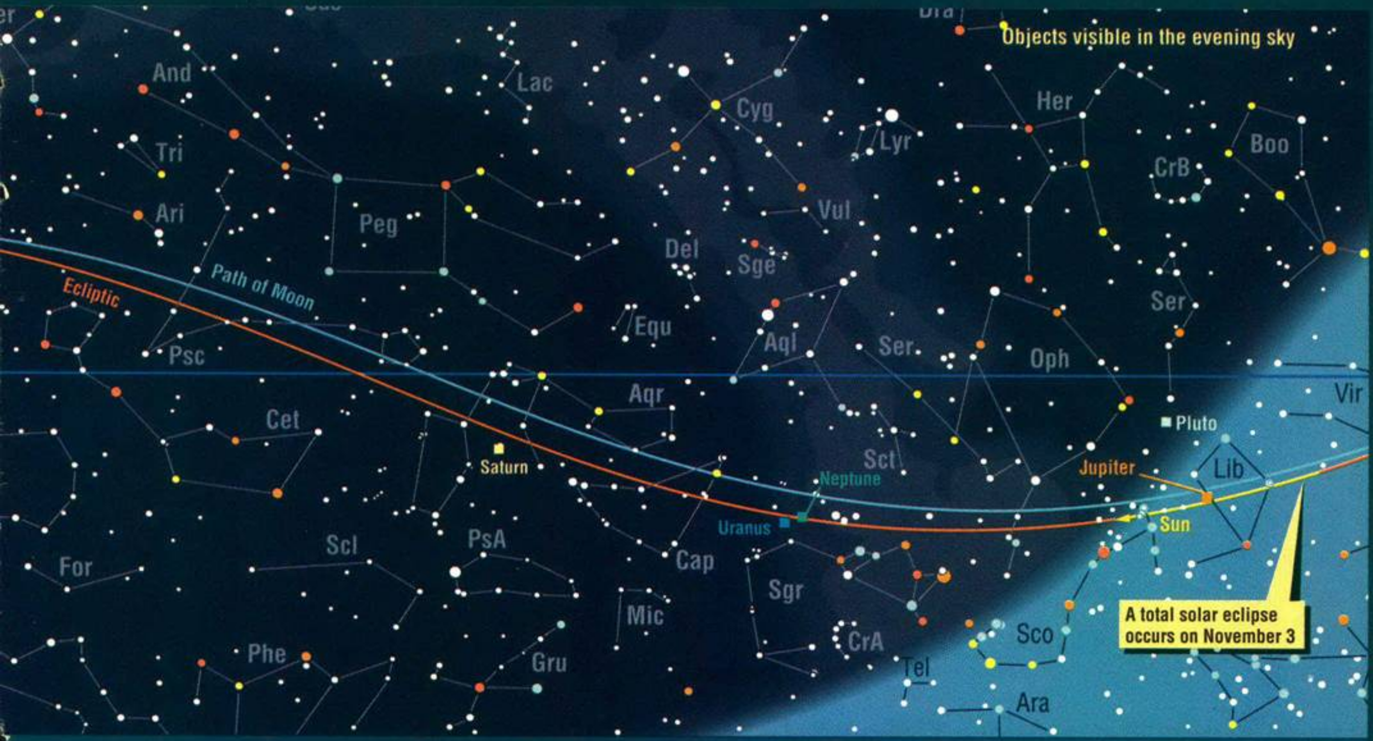


PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	November 1	November 15	November 15	November 30	November 15
Magnitude	0.1	–0.8	–4.4	–4.6	0.6
Angular Size	7.9"	5.6"	57.9"	46.8"	7.6"
Illumination	35%	84%	5%	18%	89%
Distance (AU) from Earth	0.855	1.201	0.288	0.357	1.229
Distance (AU) from Sun	0.309	0.372	0.722	0.720	1.600
Right Ascension (2000.0)	13h20.7m	14h18.6m	14h3.7m	14h5.3m	9h35.1m
Declination (2000.0)	–6°34'	–11°52'	–15°13'	–11°48'	16°24'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 6 a.m. EST on date shown. South is at top to match the view in a telescope.




Objects visible in the evening sky
And
Lac
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Boo
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Path of Moon
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Aql
Ser
Oph
Psc
Aqr
Vir
Cet
Pluto
Sct
Saturn
Neptune
Jupiter
Lib
Uranus
Sun
Scl
PsA
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Cap
Sgr
Mic
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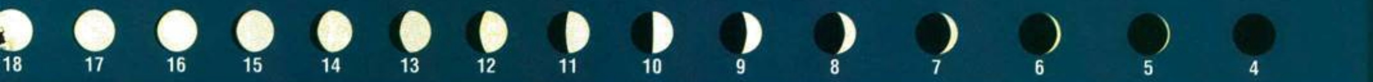
Tel
Ara

A total solar eclipse occurs on November 3

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.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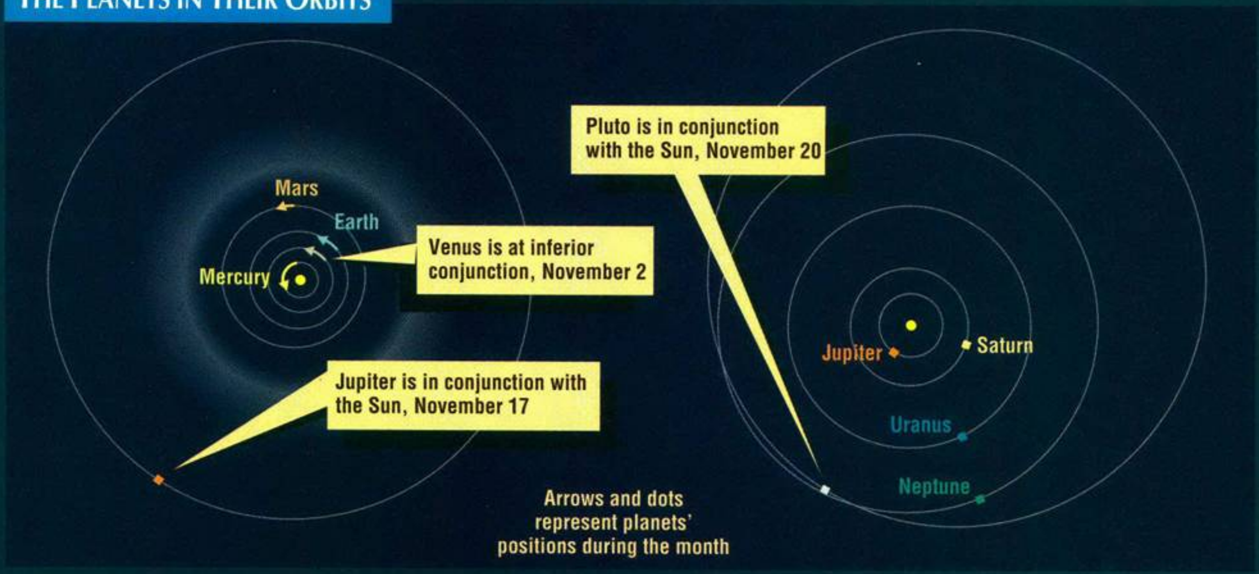
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
November 15	November 15	November 15	November 15	November 15
–1.7	0.8	5.8	8.0	13.8
31.0"	17.7"	3.5"	2.2"	0.1"
100%	100%	100%	100%	100%
6.381	9.419	20.148	30.677	30.764
5.392	9.695	19.684	30.175	29.807
15h29.8m	22h32.9m	19h40.5m	19h30.8m	15h53.8m
–18°10'	–11°11'	–21°56'	–21°13'	–6°42'

THE PLANETS IN THEIR ORBITS


Mars
Earth
Mercury
Jupiter
Saturn
Uranus
Neptune

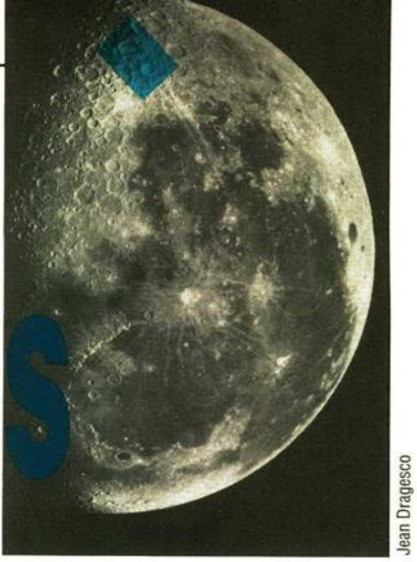
Pluto is in conjunction with the Sun, November 20

Venus is at inferior conjunction, November 2

Jupiter is in conjunction with the Sun, November 17

Arrows and dots represent planets' positions during the month

A STROLL THROUGH TYCHO and CLAVIUS



Jean Dragesco

IMPACT UPON IMPACT SCOURED the southern lunar highlands, creating thousands of small craters and two behemoths: Clavius and Tycho. South is at top in all photos to match the view in an inverting telescope.

The Moon's youngest large crater lies near an ancient walled plain in the jumble of the lunar highlands.

by Michael T. Kitt

The southern lunar highlands offers a forbidding scene of crater impact upon crater impact, a testament to the potent forces that ruled the fledgling solar system. This chaotic region is one that even experienced lunar observers tend to find confusing. Indeed, some find it easier to navigate the island galaxies of the Coma/Virgo cluster than to "crater-hop" in the lunar highlands.

Yet lying in this vast, pock-marked expanse are two lunar formations impossible to miss and well worth observing. The slightest optical assistance, even 3x opera glasses, will bring the craters Tycho and Clavius clearly into view. And if you enjoy an observing challenge, try to detect Clavius with the naked eye.

Let's begin our tour of this area on a night near Full Moon. The brightly lit lunar globe offers many treasures for backyard astronomers with small telescopes observing at low power. Certainly one of the most impressive and most obvious is the magnificent system of rays emanating from the crater **Tycho**. The impact that formed Tycho not only created the 85-kilometer-wide crater but also sprayed millions of tons of pulverized rock thousands of kilometers across the lunar nearside.

The stark white rays appear prominent because they are so young — just 109 million years old, a blink of the geologic eye in the Moon's 4.6 billion year history. Brightness equals youth on the Moon because radiation from the Sun gradually darkens fresh impact ejecta. The relative prominence of Tycho's rays varies from one night to the next as the angle of solar illumination changes, but eight to ten generally stand out, giving the Moon the appearance of a peeled orange.

The most conspicuous ray is the famous "double-ray," which trends northwest into Mare Nubium. Moving counterclockwise from the double-ray (as seen through an inverting telescope with south at top and lunar east to the left), you'll note a large zone extending almost 120° that contains only short and indistinct rays. Astronomers have no ready explanation for this zone of exclusion, but a number of other rayed craters exhibit a similar effect. Next comes a bright ray that extends southwest and then another that heads toward the Moon's south pole. This ray crosses Clavius and thus aids in locating that crater when the Sun is high in the lunar sky and details appear indistinct.

Continuing in a counterclockwise direction, next comes a very long ray that can be traced eastward all the way to Mare Nectaris. Last, at least two more rays trend northeast toward Mare Tranquillitatis and Mare Serenitatis. The Serenitatis ray neatly bisects the small but prominent crater Bessel.

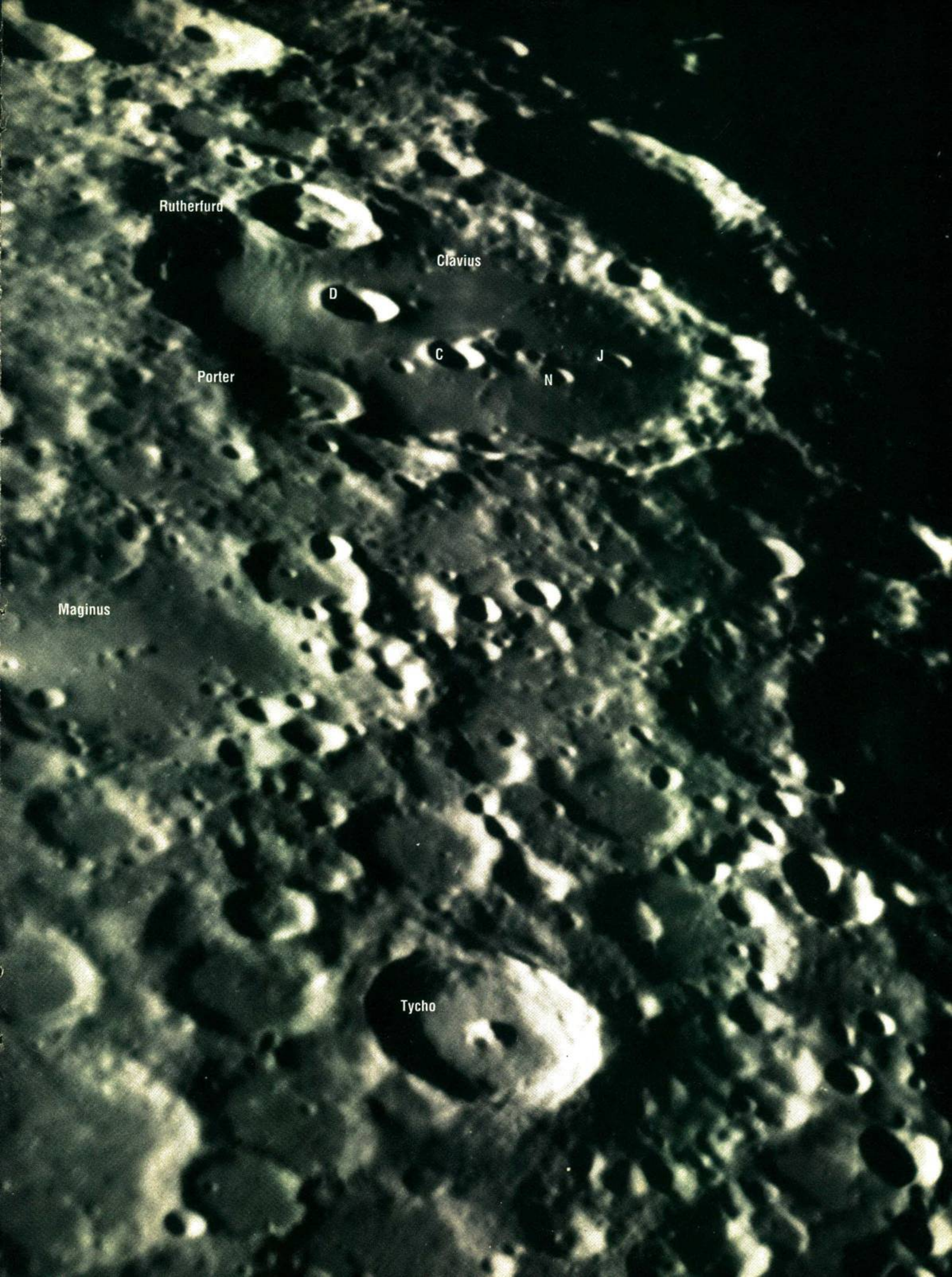
Interspersed with these major rays are a myriad of shorter ones. As the Sun's height above the lunar horizon changes from night to night, these take turns at becoming relatively brighter or dimmer. Under excellent observing conditions with a 6-inch or larger telescope, it is possible to begin resolving portions of these rays into tiny craterlets, which represent secondary impacts from the Tycho event, with their individual sprays of ejecta,. But in general the rays are as wispy and amorphous as clouds and defy any attempt to resolve detail, practically disappearing from view as you pump up the magnification.

Moving back to Tycho itself, the most noticeable feature is a dark band, or annulus, surrounding the crater. The band most likely represents dark material excavated from deep in the highlands' crust by the Tycho impact. To fully appreciate this feature, observe Tycho later in the lunar day, as noontime approaches this region around the time of Full Moon.

At local sunrise, Tycho would be quite difficult to pick out from the surrounding cratered terrain were it not for the part of the ray system that extends far into the Moon's eastern hemisphere, which is already illuminated and points right back to the crater. As the Sun rises over Tycho, the crater's massive central peak comes into view, first appearing as a starlike point of light in the jet-black crater bowl. A night or two later, the early morning Sun reveals an extensive network of terraces that dominate the inner walls. Most striking at this time is the enormous system of secondary craters strewn around Tycho. But you won't find many secondary impacts in the area immediately surrounding the crater, where the dark band will later become visible.

Of all the larger craters on the Moon, Tycho is one of the youngest. This can be seen in any size telescope

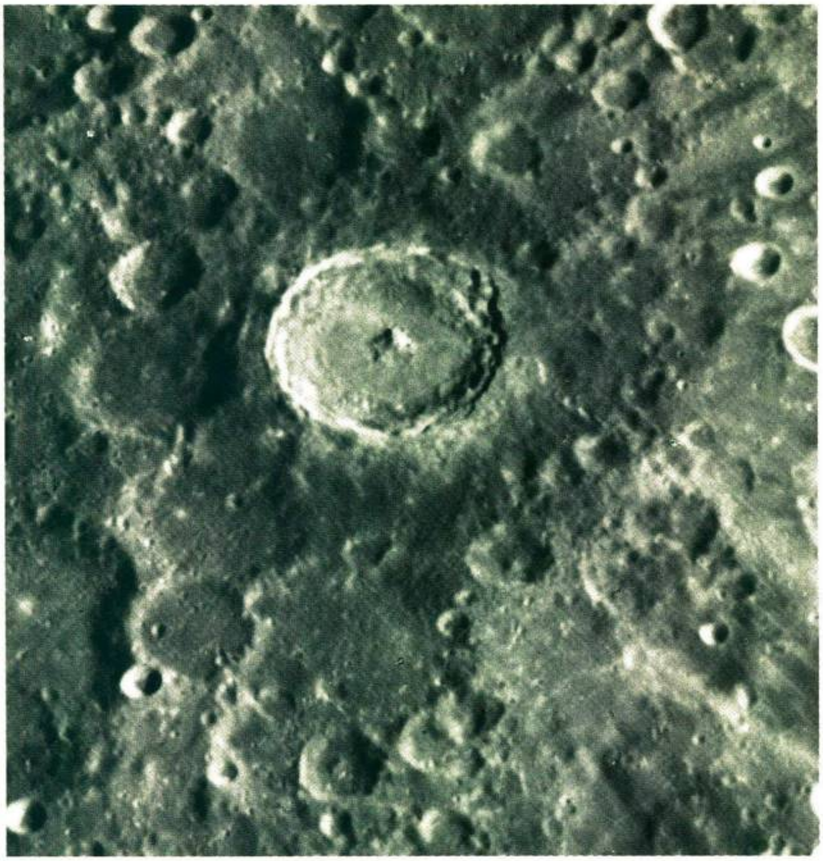
Jean Dragesco


Rutherfurd
Clavius
D
C
J
N
Porter
Maginus
Tycho

because details appear sharp and well-preserved, not degraded as in older craters that have been worn down by the glacially slow process of erosion by micrometeorites. In the 1960s, Tycho was studied extensively by the Lunar Orbiters and by Surveyor 7, which soft-landed near Tycho's northern rim. But it was Gene Cernan and Jack Schmitt, the astronauts of Apollo 17, who provided the most important detail about Tycho. From their landing site in the Taurus-Littrow valley on Mare Serenitatis, thousands of kilometers from the crater, Cernan and Schmitt sampled material in Tycho's rays. Later, scientists on Earth dated the ejecta at a mere 109 million years old.

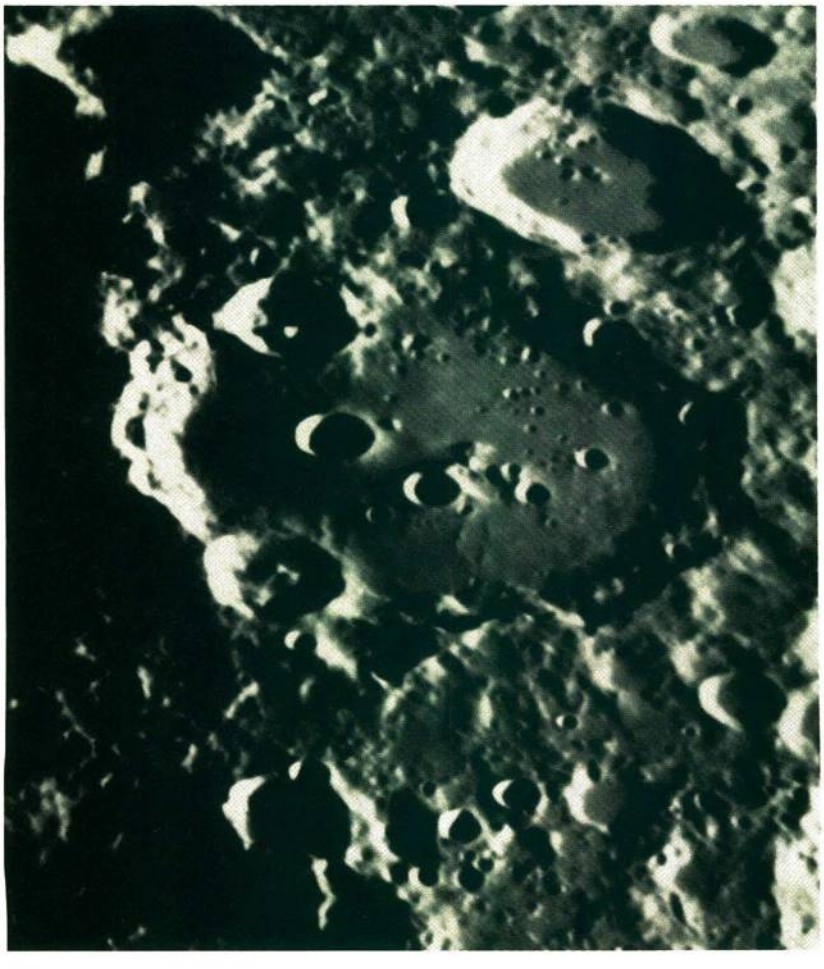
On the same nights you observe Tycho, shortly after First Quarter Moon, swing about three crater diameters south to find the much larger crater **Clavius**. At 225 km in diameter, Clavius ranks as one of the largest craters on the Moon's nearside. Other craters this large are ancient derelicts that have been battered and nearly destroyed by the continual pelting of the Moon with debris from space. Clavius — while still old as craters go — is well preserved and located for convenient observation each month.

The hallmark feature of Clavius is a chance alignment of five craters that form a sweeping arc across its floor from southeast to west, with each successive crater proportionally smaller than the last. The largest of these, 50-km-wide **Rutherfurd**, is nestled just inside the southeast edge of Clavius' rim. A fresh crater, Rutherfurd has a group of large central peaks and an ejecta blanket that creates an unusual tracery on the smooth floor of Clavius. Moving along the arc of craters from Rutherfurd, we come to the bowl-shaped craters **Clavius D**, **C**, **N**, and **J**. Just southwest of Clavius C is Clavius' minuscule group of central peaks — far out of proportion to



Lick Observatory

THE BOWL-SHAPED CRATER TYCHO (above) sports a massive central peak and an extensive network of terraces along the inner walls. But the most impressive aspect of this 85-km-wide crater is the magnificent system of rays that extends for thousands of kilometers and is seen best around Full Moon



Christian Arsidi

CLAVIUS IS AN ANCIENT, eroded impact feature stretching 225 km across that contains a prominent arc of five younger and smaller craters.

L. Loechel

the walled plain's great size. Surprising as it may seem, an astronaut standing beside these peaks would be totally unaware of the huge outer walls of Clavius, because the Moon's curvature is so great that these walls, being over 100 km distant, would lie well below the horizon.

An intriguing and beautiful effect happens every month as the Moon's terminator passes over Clavius. As the Sun rises progressively higher, the rims of Rutherfurd and the nearby crater **Porter** become illuminated first and present the appearance of bright rings suspended over the inky black depths of Clavius. In turn, the same effect can be seen with each of the smaller craters forming the arc across the floor of Clavius.

Because of its great size, Clavius is the only crater on the Moon detectable with the naked eye, but you'll need perfect timing to do it. If you look at the Moon just one day after First Quarter, the terminator will be passing across Clavius. (Some months this event occurs when the Moon is high over Earth's Eastern Hemisphere, and North American observers miss it.) At this time, the walls of the crater will be brightly lit, while they also prevent sunlight from entering the interior, keeping it inky-black. Then Clavius appears as a dark notch in the sweeping arc of the lunar terminator. It definitely helps to first observe this with binoculars or a small telescope. Then, once you know what to look for, it can be detected easily with no optical aid at all. □

Michael T. Kitt is an experienced lunar observer and author of The Moon: An Observing Guide for Backyard Telescopes *(Kalmbach, 1992).*

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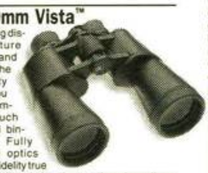

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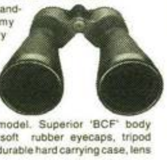

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16x80 model 5mm exit pupil, 3.5° field of view. #9482 **$299** (7.76)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

Sale!
14x100 #9495 **$899** (14.00)
25x100 #9497 **$999** (14.00)
Shipped by FedEx only.

Observing Aids

Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside Dimensions shown)

Small Case (shown) 11"x7"x3" #5951 **$17.95** (2.78)
Medium Case 12.5"x9"x5" #5952 **$26.95** (3.36)
Large Case 16"x11"x5" #5953 **$49.95** (5.19)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.
8" Celestron/Meade SC #4200 **$44.95** (2.98)

Other sizes available for scopes 3.5" to 14" —See our catalog for details.

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.
8" Dew Zappers—fit all Meade & Celestron 8" SCs DC #3503, AC #3504 **$47.95** (2.98)
10" Dew Zappers—fit all Meade 10" SCs DC #3506, AC #3508 **$54.95** (2.98)
11" Dew Zappers—fit all Celestron 11" SCs DC #3510, AC #3512 **$59.95** (2.98)

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.
8" Model #15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)

Now available for Deep Space Explorers!
Ask about other sizes.

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 **$42.95** (4.70)
Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 **$94.50** (8.02)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Nitewriter Pen #5709	**$9.95** (1.79)
Hands-Free Flex Light #5707	**$17.95** (2.43)
Starlite LED Flashlight #5714	**$24.95** (2.43)
Celestron LED Flashlight #5720	**$21.95** (2.43)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

***NEW!** Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$15.95** (2.43)

Color Eyepiece Filters

Made from absolutely the highest quality photographic-grade precision-ground optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. The black anodized, machined aluminum cells thread into any standard eyepieces, or into our universal camera adapters.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510 **$46.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$54.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets. #5517 **$99.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set. #5575 **$144 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow. #5513 **$89.95 set** (2.98)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

The finest available, SkyGlow™ filters from Orion make detailed deep-sky observing possible from light polluted city and suburban locations. Sophisticate multi-layer technology actually absorbs light pollution! Greater blocking and higher transmission than competitive models. See catalog for details..

SkyGlow UltraBlock Filters–
Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces.	#5654	**$99.95** (3.45)
2" UltraBlock Filter–fits 2" eyepieces.	#5657	**$149** (3.67)
.965" UltraBlock Filter–fits .965" eyepieces.	#5655	**$79.95** (2.98)
SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.	#5656	**$149** (3.67)

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.	#5660	**$79.95** (3.45)
SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes.	#5658	**$99.95** (3.45)
52mm Broadband Filter–For 52mm camera lenses. (Adapter rings available for other diameters.)	#5668	**$87.50** (3.45)
2" Broadband Filter–fits 2" eyepieces.	#5659	**$119** (3.45)
.965" Broadband Filter–fits .965" eyepieces.	#5661	**$49.95** (2.98)

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Accessories

Call Toll-Free For Our Huge 100 Page Catalog and See Even More!
Orion Accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.
.965" #5268 **$27.95** (2.98)
1.25" #5264 **$29.95** (2.98)
Hybrid 1.25"/.965" #8782 **$29.95** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.
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Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.
#7012 **$64.95** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.
#5014 **$19.95 ea.** (2.43)

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For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.
Standard Tele-Extender #5125 **$29.95** (2.98)
Variable Tele-Extender #5127 **$39.95** (2.98)

T-Adapters for SC and MAK

Threads to rear cell of telescope, requires t-ring for your camera model.
for SC #5116 **$26.95** (2.98)
for C-90 #7115 **$34.95** (2.98)

T-Rings for all 35mm Cameras

Available for many different camera types, call toll-free or see our catalog for your particular model.

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.
1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792
$44.95 (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.
1.25" Star Diagonal #8763 **$49.95** (2.98)
.965" Star Diagonal #8761 **$29.95** (2.98)
Hybrid 1.25"/.965" Star Diagonal #14008 **$33.95** (2.98)

Orion Ultra™ 2" Diagonals

Your SC or refractor deserves the finest. Both models are the finest optical quality and use the best coatings available.
2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771 **$219** (4.71)
2" Mirror Diagonal– Affordable, high-quality first-surface optical flat star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$109** (3.45)

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Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few hours!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets. #7801 **$199** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice. #7802 **$319** (4.44)

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Gigantic 10,000 object database, expanded subject descriptions, RS-232 port. #7803 **$469** (6.78)

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Installation packages are available for most telescope models. Call for details.
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Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.
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Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.
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Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.
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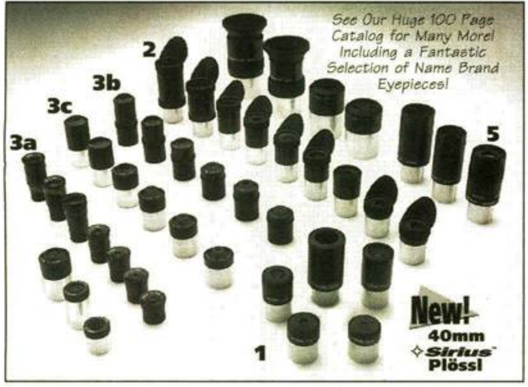
Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.
#2354 **$109** (8.97)

Eyepieces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2
3b
3c
3a
5
1
New!
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You could pay nearly twice the price for "famous name" Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!
Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The Classic 4-element Plössl design is renowned for its fantastic performance and has become the standard by which all other eyepieces are compared.

The Fully Magnesium fluoride coated optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

26mm #8732, *17mm* #8734, *10mm* #8736, *7.5mm* #8738 **$57.95 ea.** (3.45)
New! *40mm* #8730 **$79.95** (3.67)
Case only #5911 **$12.95** (2.19)

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*Bonus—**Free case** with purchase of 2 or more!*

2 Orion 5-Element Ultrascopic™ Eyepieces

With superb Ultra™ Multi-Coatings!

Made for Orion by Japan's finest lens maker, Ultrascopic eyepieces yield the highest contrast, greatest light transmission, and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on *every* surface, they achieve a level of performance "name brand" 4-element models can't match. Wide 52° flat field of view. Removeable contoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs which yield surprisingly long eye relief. Absolutely guaranteed to knock your socks off!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$89.95 ea.** (3.45)

Wide Field 5-element **25mm** #8564 **$99.95** (3.45)
30mm #8562 **$109** (3.45)
35mm #8560 **$119** (3.45)
High Power 7-element *—Long Eye Relief*
5mm #8574, **3.8mm** #8576 **$99.95** (3.45)

3 Orion Explorer™ Multi-Coated 1.25" & .965" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

b *1.25" Orthoscopic*
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$57.95 each (2.98)

c *1.25" Kellner*
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$47.95 each (2.98)

a *.965 Orthoscopic*
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 **$49.50 each** (2.98)

a *.965 Kellner & Achromatic Huygenien*
K 18mm #8584, **K 25mm** #8585, **AH 40mm** #8586
$37.50 each (2.98)

Illuminated Reticle Eyepieces

A necessity for long exposure astrophotography and very useful for polar alignment.

12.5mm Plössl Illuminated Reticle 1.25"
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$119** (3.45)

9mm Orthoscopic Illuminated Reticle 1.25"
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$129** (3.67))

12mm Kellner Illuminated Reticle 1.25"
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$74.95** (3.45)

12mm Kellner Illuminated Reticle 1.25"
Same as 8482 above except has a wireless illuminator. Needs 2 SR-44 batteries, not included.
#8481 **$99.95** (3.45)

SR-44 Batteries (pkg. of 2) #2360 **$5.95** (1.79)

5 UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.
#8556 **$179** (3.67)

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$39.95** (2.98)
1.25" #8746 **$46.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$64.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$59.95** (3.45)

Shorty Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.
.965" #8710 **$44.95** (2.98)
1.25" #8711 **$54.95** (3.45)

Quality Components for Building or Upgrading

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors

Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors

Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with standard or 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with standard or high reflectivity Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis.
See catalog for pricing.

6x30 Achromatic Finder Scopes

6x30mm—Same unit used on $1000+ "big name" telescopes. With 2-ring metal bracket, fits scopes 6"-12".
#13023 (white) **$49.95** (3.41)

6x30mm Right Angle—90° prism for right-angle viewing. Includes bracket.
#13021 (white) **$74.95** (3.41)

Large Aperture Finder Scopes

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separately.)

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil.
#7090 (white) #7094 (black) **$69.95** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness.
#7092 (white) #7096 (black) **$99.95** (3.41)

9x60mm — 44% more light grasp than 50mm models.
#7091 (white) #7095 (black) **$99.95** (3.41)

9x60mm Illuminated—Wireless illuminator with adjustable brightness.
#7093 (white) #7097 (black) **$139** (3.41)

Superb Dovetail Aluminum Mounts for 50mm and 60mm Finder Scopes

Instantly install or remove your finder, without tools, without disturbing alignment! Black anodized, Fits any scope 6" and over including Celestron & Meade SCs. *(pictured above)*
8x50mm bracket #5040 **$37.50** (2.45)
9x60mm bracket #5041 **$44.50** (2.98)

Low-Profile Helical Focusers

Economical yet precise focusing. Ideal for fast optical systems. Cast aluminum base with threaded machined aluminum inner tube.
1.25" #13014 **$39.95** (2.45)
2.0" #13016 **$64.50** (2.98)

Rack-and-Pinion Focusers

Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.
1.25" #13007 **$59.95** (2.98)
2.0" includes 1.25" adapter.
#13003 **$99.95** (3.95)

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- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in parentheses after each price. We ship to U.S. and Canada only.
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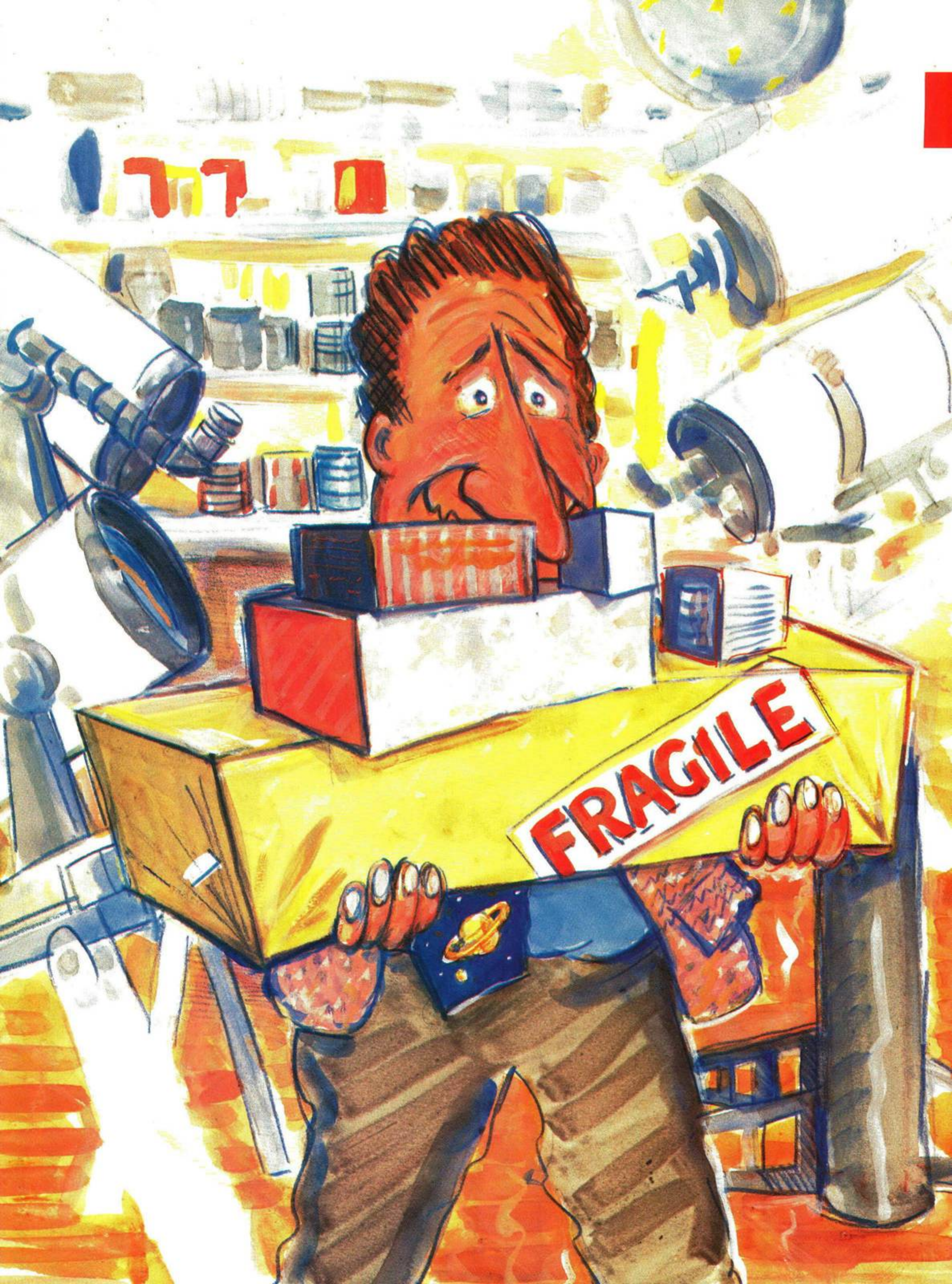

FRAGILE

T is for Telescope

For the first-time buyer, it's a real jungle out there. Maybe it's time to have a heart-to-heart talk and clear a path.

by John Shibley

Jeez. Here I am with a couple of thousand dollars to spend — or is that only a few hundred? — but I'm overwhelmed by all those ads in astronomy magazines, those catalogs, all those statistics . . . focal ratios, wide-angle eyepieces, accessories galore. Do I want to do planetary observing or deep-sky photography? Argh! Maybe I should take up a simpler hobby.

Don't do that.

Huh? I'm hearing voices now — thinking about this astronomy hobby is driving me nuts.

No, I'm not a paranoid fantasy. I'm the voice of experience, someone to whom your problems sound all too familiar. In fact, at one time I even considered a more down-to-earth hobby. But nothing compares to the high I get from astronomy.

Okay, maybe you can tell me what scope to buy. What scopes do you own?

Several, because certain designs work best for different types of observing. My 13.1-inch f/4.5 Dobsonian reflector is for hunting down deep-sky objects. The 4-inch f/15 refractor I use for lunar and planetary observing and photography. I own a 70mm f/6.8 scope that's easy to take on trips. I have a 10-inch f/4.5 equatorial reflector for deep-sky astrophotography . . .

Whoa! I have enough money to buy only one scope.

The point is that as I've grown into astronomy, I've acquired specialized scopes to delve deeper into various types of observing. It's sort of like having a 4WD truck for off-road driving and a sports car for cruising the highway.

Some of us aren't made of money like you are.

Wait a minute. I'm certainly not made of cash. I have budgeted appropriately over 20 years' time, making equipment purchases carefully as my interest and expertise have grown. The main ingredient isn't money, it's patience.

Well, I don't know if I'm gonna be in astronomy for 20-odd years. Whether I get the right scope might determine that, I guess. But if I sample astronomy and find out it's not my cup of tea I don't want some mega-bucks telescope sitting in some corner of my house taunting me for not following up on "The Investment."

Your concern raises an important point and I do have some advice. Enter astronomy in increments and keep your initial equipment purchases simple. All those specialized doodads will still be around to buy, maybe even improved, after you've had a chance to sample astronomy. Your main task now is to get the "lay of the sky," and that means learning constellations, following the Moon and planets' motions and discovering the elegant simplicity of naked-eye observation.

Okay, let's say I do learn the sky . . . then what?

Then make the jump from naked-eye astronomy to using binoculars or a simple telescope.

Binoculars? I thought to really see *things you had to have some high-powered telescope.*

Nope. Binoculars offer a gentle transition into "magnified" astronomy, a bridge from naked-eye observing. With a good set of binoculars you can see craters on the Moon, double stars, open clusters, galaxies, moons around Jupiter, plus much more. Because your brain is more comfortable working with information from two eyes rather than from one, you can see fainter objects than you might think.

What's a good astronomical binocular?

A pair of 7x50s. The first part of the label gives what power they provide — 7x — while the second part conveys the diameter of the front lens, 50mm. Your pupils, when dark adapted, are 7mm in diameter. In a manner of speaking, binoculars enlarge your pupils over seven times and gather 50 times the light.

How much does a good pair cost?

You can pay more, but a couple of hundred dollars will get a pair you can use forever. And if your interest in astronomy wanes, you've got a good set of glasses for other uses, like birdwatching. But the best part about binocs is that they're easy to use — just walk outside and lift them to your eyes. And you can

Optics Gather the Light

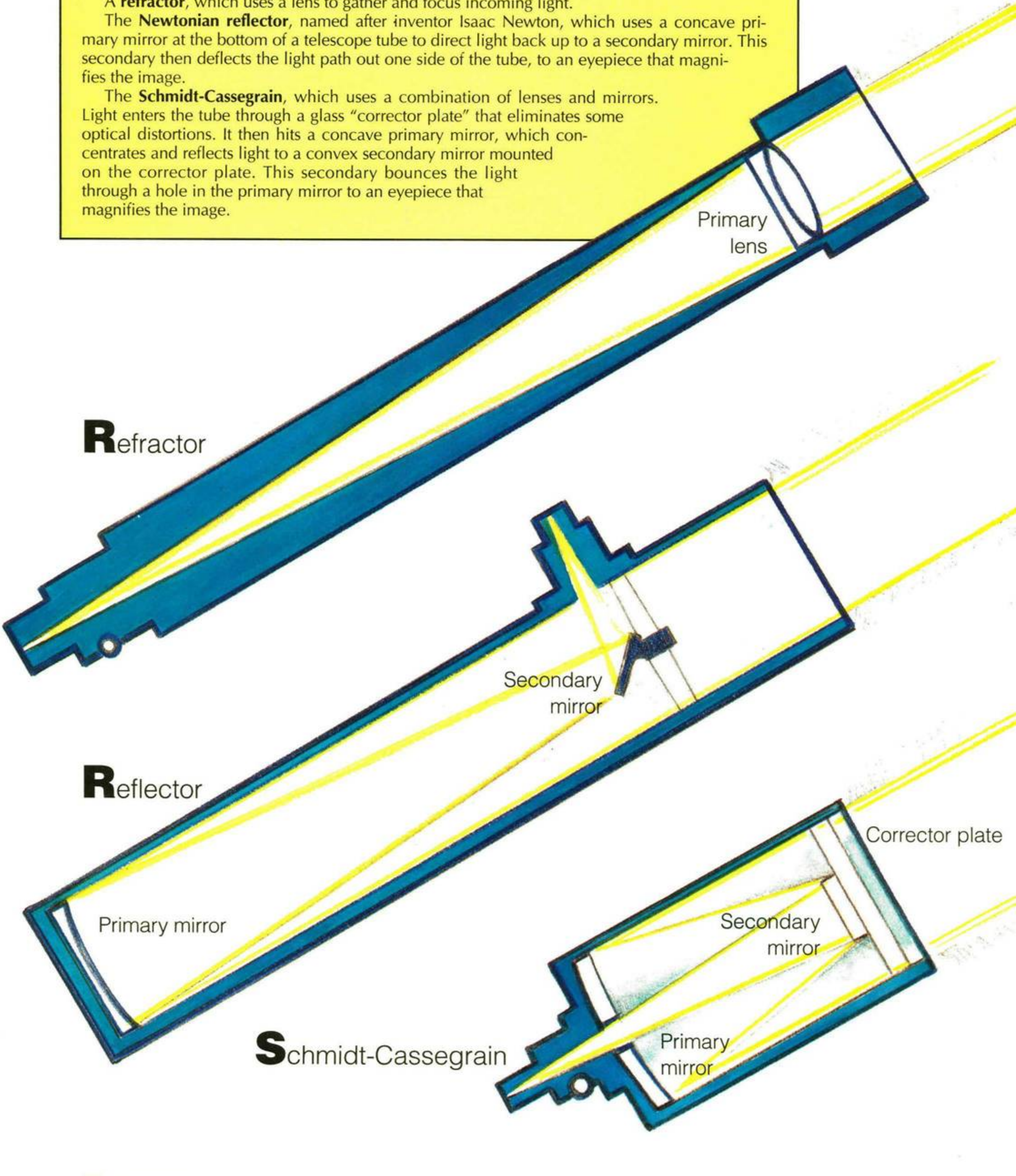
Telescopes collect light and bring it to a focus so observers can see details on the Moon, planets, and deep-sky objects.

Most scopes consist of three basic designs:

A **refractor**, which uses a lens to gather and focus incoming light.

The **Newtonian reflector**, named after inventor Isaac Newton, which uses a concave primary mirror at the bottom of a telescope tube to direct light back up to a secondary mirror. This secondary then deflects the light path out one side of the tube, to an eyepiece that magnifies the image.

The **Schmidt-Cassegrain**, which uses a combination of lenses and mirrors. Light enters the tube through a glass "corrector plate" that eliminates some optical distortions. It then hits a concave primary mirror, which concentrates and reflects light to a convex secondary mirror mounted on the corrector plate. This secondary bounces the light through a hole in the primary mirror to an eyepiece that magnifies the image.


Primary lens
Refractor
Secondary mirror
Reflector
Primary mirror
Corrector plate
Secondary mirror
Schmidt-Cassegrain
Primary mirror

throw them on a car seat and drive away from city lights. Even after you buy a scope, binoculars are invaluable tools for locating telescopic targets.

All right, you said something about a "simple" telescope?

Again, the important thing is simplicity. At times absorbing astronomy can seem overwhelming, so keeping your ability to view the heavens as easy as possible increases the chances of sticking with it. Go with a scope that can be set up easily in a matter of minutes. Don't let a scope's complexity and lengthy set-up time become an excuse for not observing.

What simple scope would you recommend?

Actually there are three possible choices. The one that's right for you depends on your observational preference. There's the refractor, which is capable of providing top-quality images (if it's not of the "department store" variety), the Schmidt-Cassegrain, which is compact, and the Newtonian reflector, which provides a lot of aperture for the money. A popular variant of the Newtonian reflector is the Dobsonian. Its optical tube sits in a boxed platform that allows the scope to move up, down, left, and right. One big drawback to the Dobsonian design is that it limits you to visual observing — no astrophotography.

Well, this a going to sound kind of dumb, but how does a Newtonian reflector work?

Essentially it uses a concave mirror, called a primary mirror, to gather light that enters the tube and bring it to a point. An eyepiece is placed near this focused point of light to magnify the image for viewing. The distance from the mirror to a point where all the light rays focus is called the focal length of the telescope, which is usually listed in millimeters.

Wait a minute: if the mirror focuses light to a point in front of the mirror, how do you use an eyepiece without standing in the light path?

There's another mirror, called a secondary mirror, that redirects the light path off to one side so that won't happen.

Ah, I see. How powerful are these Newtonian reflectors?

Well, the true measure of any telescope's performance is the amount of light it gathers. The bigger the mirror, the more light it gathers, and the fainter the objects it will show with more resolution. A mirror that's 10 inches in diameter will see dimmer objects than a 6-inch, and it'll be able to see objects with better clarity. A 16-inch will see more than a 10 and with even more sharpness.

Why all the hype about power?

From a marketer's point of view, it works well as a marketing tool with naive buyers. I suspect when the word "power" is uttered, many buyers picture Mr. T (as in Telescope) kicking the door in on the Hall of Cosmic Mysteries. In that vein, a powerful scope (500x . . . 1,000x . . . 5,000x!!) is deemed to be more desirable in the collective minds of consumers. The size, or aperture, of a telescope's primary mirror (or in the case of a refractor, the lens), determines light grasp, resolution and, ultimately, how much magnification or "power" an observer can apply usefully.

How is a telescope's power determined?

Power, or magnification, in a telescope is varied by changing eyepieces. To figure out what power an eyepiece will yield with your scope, divide the focal length of your telescope by the focal length of the eyepiece. The eyepiece's focal length should be printed prominently on the eyepiece barrel.

If I have the right kind of eyepiece, I should be able to observe at 800x, right?

Yeah, you could, but observers hardly ever use extreme powers. At progressively higher magnification, images tend to get fuzzier and fainter. On most nights it's the steadiness of the air that determines how high a power you can observe at. As a rule of thumb, the highest usable power any telescope will give works out to about 50x per inch of aperture. That translates to 200x for a 4-inch scope and 400x for an 8-inch.

Maximum power aside, will a 20mm eyepiece give me the same power on any 8-inch telescope?

Nope. How concave a mirror's surface is determines its focal length. If a mirror has more curvature, it's focal length will be shorter. Not all mirrors (or in refractors, lenses) of similar aperture have the same focal length. To calculate magnification, you've got to know the telescope's focal length.

One scope ad I looked at didn't give the focal length, but something called an f/ratio. What's that?

An f/ratio relates a scope's aperture to its focal length. The f/ratio of a telescope is its focal length divided by the aperture. So a 200mm (8-inch) telescope with a 2,000mm focal length has an f/ratio of 10, or f/10. Sometimes people describe a scope by stating only its aperture and f/ratio, as you saw in that ad. To find a telescope's focal length, just multiply its aperture by the f/ratio. For example, a 13.1-inch f/4.5 has a focal length of 328 mm (13.1 inches x 25 = 328) times 4.5, or 1,480 mm.

Why all the different f/ratios and focal lengths?

Telescopes with shorter focal lengths (400 mm to 700 mm) provide low powers and wider fields of views with a given eyepiece than telescopes with longer focal lengths (1,300 mm to 3,000 mm). For this reason, short focal lengths are often preferred for wide-angle viewing of deep-sky targets and Milky Way starfields. On the other hand, a long focal-length scope gives a higher power with any given eyepiece. The planets require higher powers (200x plus), so planetary observers often prefer scopes with longer focal lengths. But with the use of appropriate eyepieces, most telescopes can be used at both low and high powers.

So if I know the scope's focal length, I can also get a rough idea of how long the telescope tube is.

In most cases, you can. Take my 13-inch Dobsonian — it has an f/ratio of 4.5, which gives it a focal length of 1,480 mm, or 59 inches. That means the tube is about five feet long and about a foot wide. If you own a compact car or have limited closet space for storage, a telescope's aperture and focal length statistics should figure prominently in your purchase plans. Keep in mind other "bulkiness" factors such as the mount and items that protrude from the tube, like finders and focusers. Also be aware of the entire system's (telescope and mount) weight. Some mounts that allow a scope to track with the sky can weigh a lot.

Does a Dobsonian track with the sky?

No, but that's not necessarily a handicap. Most of what there is to observe with a telescope can be viewed at 100-power or less. At that magnification, it's very easy to follow an object as it moves through the eyepiece's field of view. The Dobsonian design uses Teflon bearing surfaces that allow for very smooth adjustments as you nudge the scope along to follow an object.

Okay, let's get to the meat of the issue — price. How much does a good beginner's scope cost?

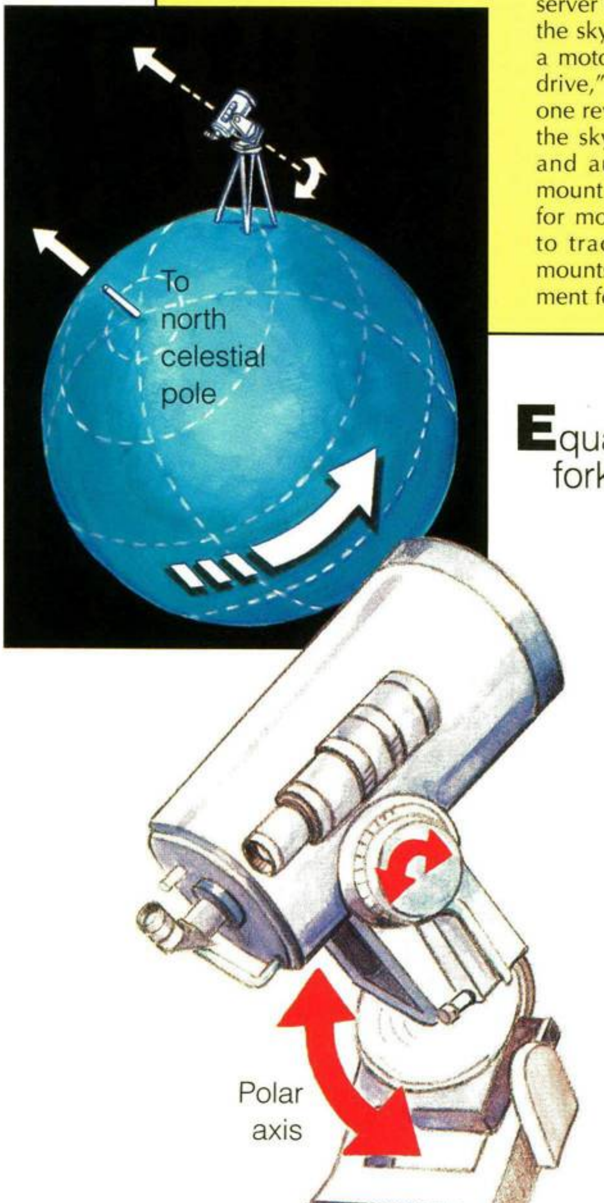
Maybe between $200 and $800,

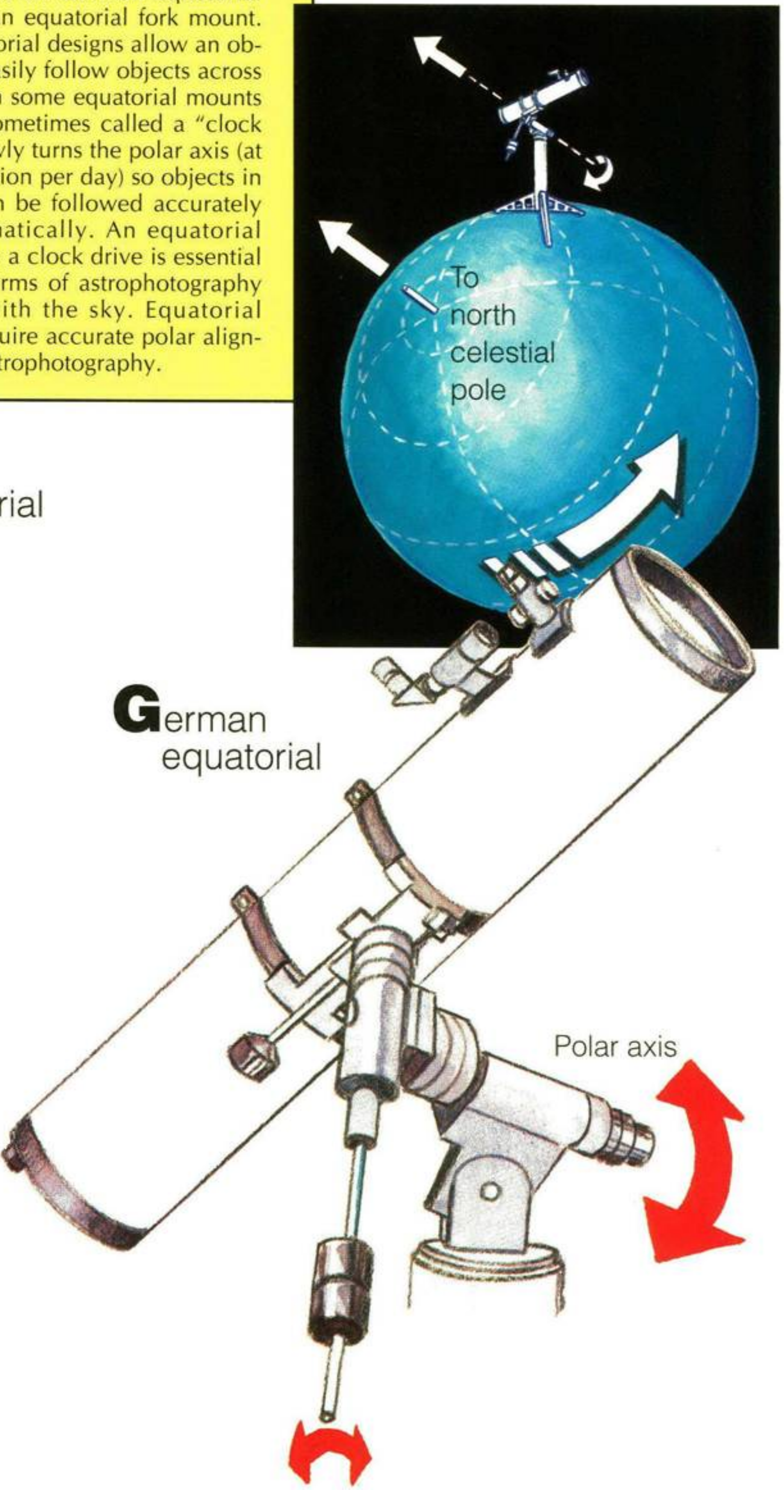
Mounts Steady a Telescope

Telescope mounts come in two types: altazimuth and equatorial.

Altazimuth mounts allow a telescope to pivot up and down (in altitude), and left and right (azimuth).

One popular type of altazimuth mount is the Dobsonian, which usually accommodates large-aperture telescopes. An equatorial mount also pivots in two directions like its altazimuth cousin, but one axis, the polar axis, points to the north celestial pole, located near Polaris. Telescopes with long tubes are usually mounted on German equatorial mounts, while compact telescopes fit into an equatorial fork mount. Both equatorial designs allow an observer to easily follow objects across the sky. On some equatorial mounts a motor, sometimes called a "clock drive," slowly turns the polar axis (at one revolution per day) so objects in the sky can be followed accurately and automatically. An equatorial mount with a clock drive is essential for most forms of astrophotography to track with the sky. Equatorial mounts require accurate polar alignment for astrophotography.





and you can get a 6-, 8-, or 10-inch Dobsonian telescope for under $500.

It sounds like Dobsonians are good for viewing, but you said earlier that they don't work for astrophotography?

Yes, for that you'll have to buy a scope that's on an equatorial mount. Such a mount is essential for astrophotography. Here's how an equatorial works: Remember how the Dobsonian pivots left and right? Suppose that left-and-right axis could be angled near Polaris, the North Star, around which all the stars in the sky appear to rotate. You could then pivot and follow the motion of the night sky. If a motor moves this axis at the right speed, the scope would follow the sky automatically.

Are equatorial mounts pretty easy to set up?

For general observing, the axis that turns with the sky, the polar axis, can simply be pointed at the North Star. But for astrophotography, the polar axis should be aligned as close to the north celestial pole as possible. Polaris is actually about one degree from the pole. That means you'll have to know how to use a star chart and how to offset the polar axis from Polaris.

Sounds like a pain.

With a small telescope (in the 2- to 4-inch range), the mounts are manageable and easy to align. Some beginner scopes on equatorial mounts have slow-motion control knobs that you turn to keep an object centered. Bigger scopes, six inches and larger, usually have beefier mounts that require more effort to align.

So if I'm pressed for space, I'm stuck with buying a smaller-aperture telescope.

Nope. The ever-popular Schmidt-Cassegrain telescope (SCT) concept allows for a larger aperture in a compact tube. This design "folds" the scope's light path back upon itself. Instead of deflecting the light path off to one side as in a Newtonian, the secondary mirror in a SCT sends the light back through a hole in the primary mirror, where the eyepiece is located. So an 8-inch f/10 SCT doesn't have an 80-inch-long tube, but one that's less than 20 inches long. On top of that, an SCT equatorial telescope is nestled in a fork that has the polar axis built into its base.

Wow! A tube that small probably fits into a carrying case or something.

SCT systems do have a reputation for portability. They usually break down into three main components: the telescope, the wedge (which tilts the scope by the right amount so the polar axis points to the North Celestial Pole), and the field tripod.

How much does a "starter" Schmidt-Cassegrain run?

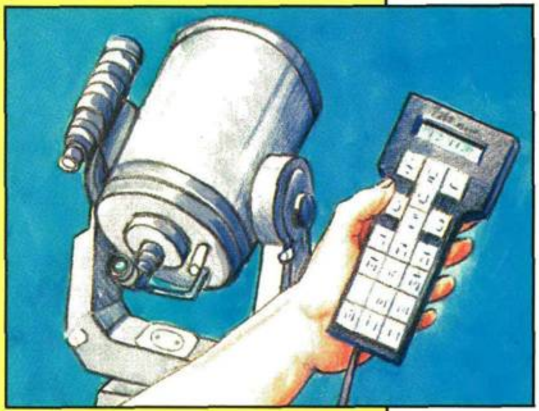
For an 8-inch f/10, which offers enough aperture for lunar, planetary, and deep sky observing and photography, about $1,300, perhaps another $800 to $1,000 to add equipment for astrophotography.

I assume an equatorial mount on a Schmidt-Cassegrain telescope has setting circles to dial in objects . . . how do they work?

Some equatorial mounts do offer these circles. In theory, you should be able to find objects by moving the scope until the circles' readings match celestial coordinates taken from a catalog. In practice most

Smart Scopes

Feel overwhelmed when it comes to finding objects with a telescope?

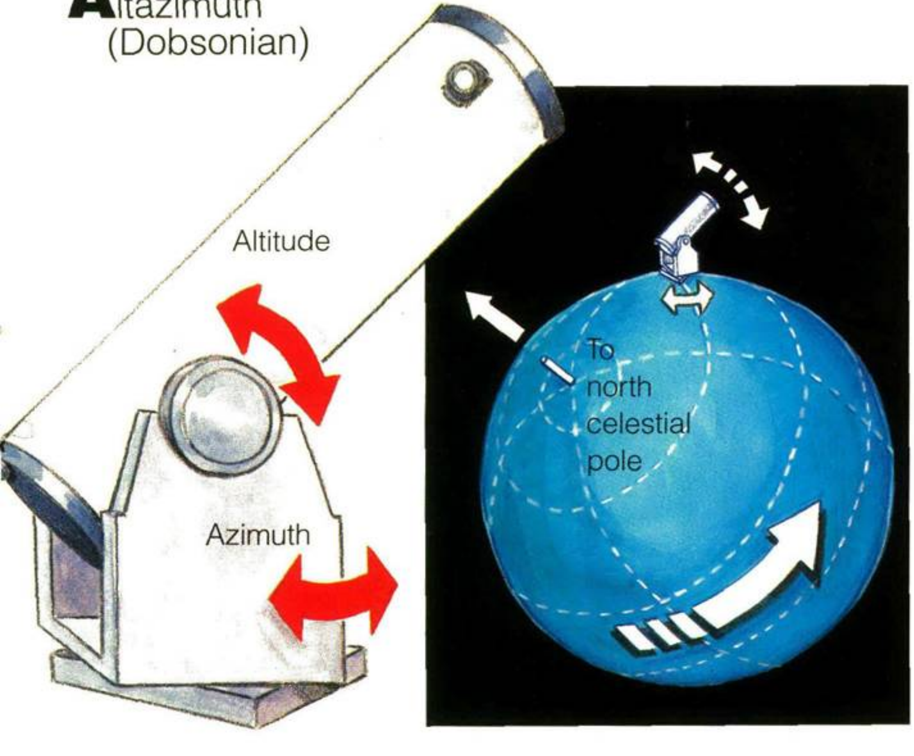


Well, thanks to the computer revolution, a scope can find objects or at the very least *help* you find them. With a computer-driven telescope, all an observer has to do is calibrate on a few bright stars and the scope does the rest. It can slew to objects and, through a digital display, give statistics about what's in the eyepiece. Some telescopes even connect to a laptop computer running popular star planetarium-type programs. Point the cursor to an object on the computer screen, click, and the scope slews to that object's location.

Don't have motors on your telescope mount? With data programmed into an on-board memory chip, digital setting circles give directions to objects. Depending on how much you want to spend, you'll find several thousand deep sky objects, planet positions, even the location of suspected black holes. Some accessories let observers custom-program their own "sky tours" or store the coordinates of recently discovered comets and novae. And now on the market are voice-activated computer programs that run telescopes.

Who knows how far this trend will go? Perhaps one day a computer will tell you it's time to come out and play. Stay tuned!

Altazimuth (Dobsonian)



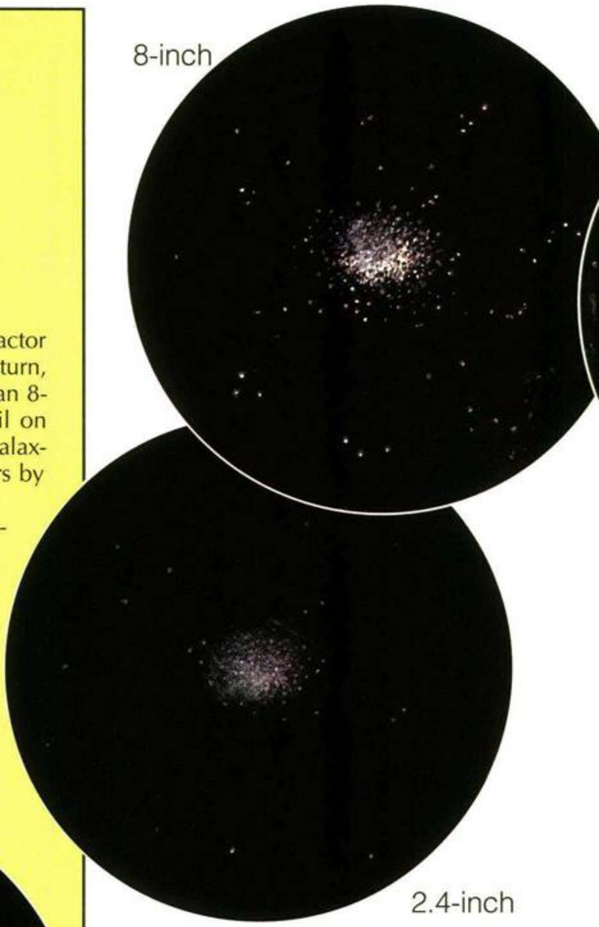
What's There to See?

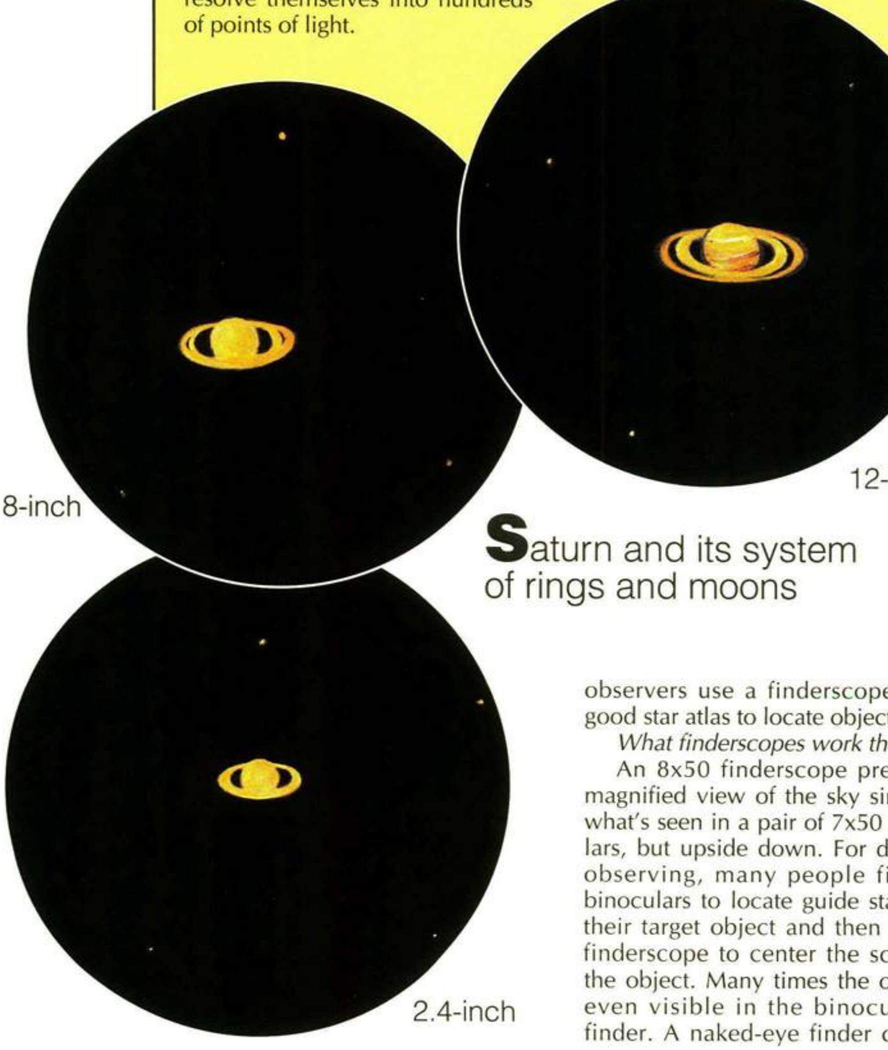
The size of your telescope's primary mirror (for a reflector) or lens (refractor) determines not only how faint you'll be able to see, but with what clarity.

Put simply, a larger aperture lets you see more. A 2.4-inch refractor will show star clusters, fuzzy galaxies and nebulae, the rings of Saturn, cloud bands on Jupiter, and craters on the Moon. But a scope with an 8-inch aperture reveals the Moon with stunning clarity, subtle detail on Jupiter, Saturn's cloud bands and a gap in its rings, and structure in galaxies and nebulae. Some star clusters even seem to gain new members by the hundreds.

Regardless of the aperture, the Moon looks fantastic in any telescope and should be the premier object for a first-time telescope purchaser. When it's closest to Earth and largest in the eyepiece, Mars sports white polar caps and dark surface markings. Even small telescopes show the greenish hue of Uranus and just start to resolve Neptune as a disk. To bag Pluto, though, you'll need at least an 8-inch telescope.

Beyond the solar system there are hundreds of deep-sky objects within the reach of 2-inch to 8-inch scopes. Galaxies and nebulae show up as swatches of blurry light, while some globular and open star clusters resolve themselves into hundreds of points of light.





Saturn and its system of rings and moons

observers use a finderscope and a good star atlas to locate objects.

What finderscopes work the best?

An 8x50 finderscope presents a magnified view of the sky similar to what's seen in a pair of 7x50 binoculars, but upside down. For deep-sky observing, many people first use binoculars to locate guide stars near their target object and then use the finderscope to center the scope on the object. Many times the object is even visible in the binoculars or finder. A naked-eye finder called a Telrad also has become popular. It projects a bull's eye onto a piece of glass you sight through toward the sky.

I've heard that certain types of telescopes work better than others when it comes to looking at the planets.

Telescopes of all designs, be they reflectors or refractors, will show the rings of Saturn or cloud details on Jupiter. Aside from the focal length considerations I mentioned earlier, some people do contend that refractors have an edge over reflectors when it comes to observing planets.

In what way?

A reflector needs a secondary mirror to redirect light to the eyepiece. That mirror sits in the light path and will scatter some of the incoming light before it hits the primary mirror. Scattered light reduces the contrast of the image, making it harder to see the very faintest details. A refractor uses a lens to bend the light to a focus and doesn't require another mirror to direct the light into an eyepiece. Thus a refractor offers *unobstructed optics*, which contribute to images that are punchier in contrast, an element crucial in detecting subtle planetary detail.

12-inch

A globular star cluster

Well, if a refractor offers good contrast for planetary observing, it must do the same for deep-sky objects.

Unobstructed optics do have an edge when it comes to contrast, but buying a refractor that resolves deep sky objects nicely — in the 4-inch range — would cost several times more than a reflector of similar aperture. There are some excellent 2- to 4-inch refractors on the market that offer exceptional optical quality and portability. But when it comes to deep-sky observing and photography, a scope's aperture is probably the single most important factor.

Why is it some refractors cost more than reflectors?

With a refractor, light passes through a front lens to come to a focus. That lens must be ground perfectly, and use costly types of glass to avoid flaws that have historically plagued refractors, like chromatic aberration. Chromatic aberration happens when all the colors in white light don't come to the same focus. A refractor with this type of problem has colored haloes surrounding bright stars when you look through the eyepiece. Some refractor makers have virtually eliminated this flaw, using special glass, multiple optical elements (with up to six optical surfaces, each of which must be ground perfectly — another source of added cost), and special manufacturing techniques. Recent advances have allowed them to market refractors that are very compact and have small f/ratios, ideal for wide-field observing.

So does a refractor give the sharpest images?

The finest images are found in quality refractors. Though they work on the same principle as department store refractors, top-notch refractors perform outstandingly well. They are expensive, but if the best possible image is desired and a large aperture isn't a necessity, then a high-quality refractor may be the way to go.

Okay, let's talk turkey: What should I tick off in my mind before buying my first scope?

For deep-sky observing, your scope should have an aperture of at least four inches. If you plan to take up astrophotography, an equatorial mount that has a motor to track the sky is a necessity. Also consider the scope's weight, bulkiness, and complexity: Can you carry it easily? Will it fit in your car? Is the mount complicated? Does it require tools to assemble? You might also want to budget for better eyepieces. Usually telescopes come equipped with bare bones, economy oculars. Orthoscopic and Plössl eyepieces perform very well, and run between $60 and $90. Your scope should also use eyepieces that have 1.25-inch barrel diameters, versus 0.965-inch, giving you a wider choice of eyepieces.

How many eyepieces should I start out with?

Three. A low-, medium-, and high-power eyepiece. Low-powered ones have focal lengths in the 20- to 30mm range, medium-powered ones in the high teens to low 20s, and high-powered ones less than 10mm.

Like a good set of eyepieces this chat has certainly sharpened my view of astronomy.

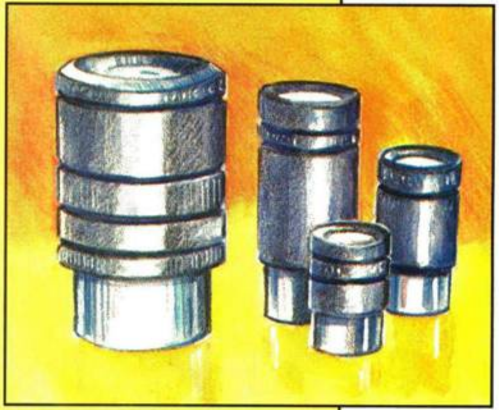
Astronomy is a growth hobby, one that will continue to enlighten and fascinate you as you learn more about what can be seen and, in most cases, photographed. Sure it's complex and full of jargon, but many human enterprises have their own language and break-in period. Never forget you are the one setting the learning pace. Read astronomy books and magazines, find a local astronomy club, or go to a star party. Last, buy a scope you're going to use and enjoy. More ambitious (and no doubt expensive) purchases will make more sense later. You'll know when the time is right. For now, though, just drink it all in. ☐

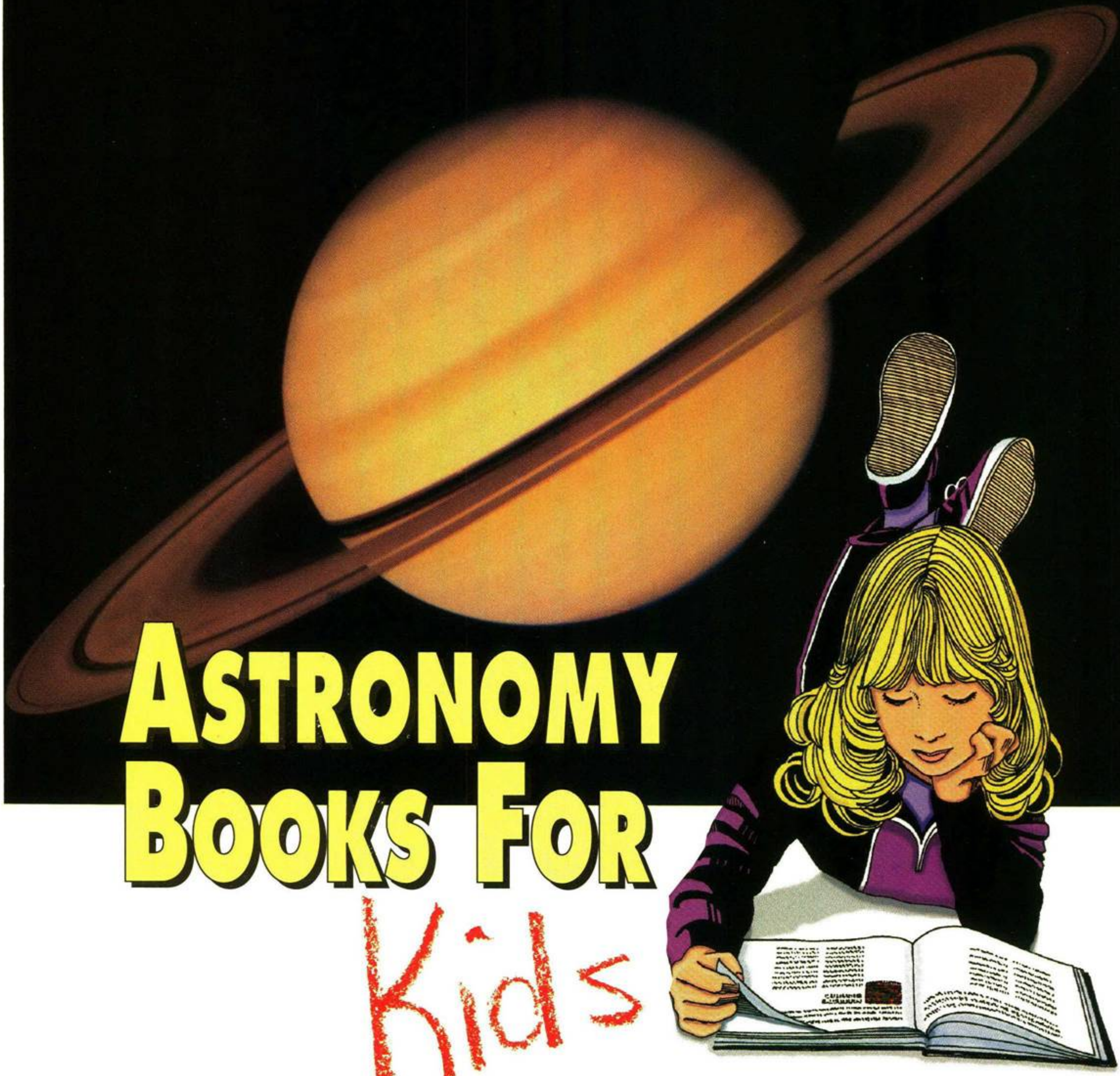
Eyepieces Provide Power

While the telescope gathers and focuses light, it's the eyepiece that magnifies and forms an image you can see.

Knowing this, selecting the right eyepiece is just as crucial as buying the right telescope. A bare-bones eyepiece collection should cover low, mid, and high powers. Low power (25x to 50x) works best on spread-out star clusters and nebulae. Middle-range powers (90 to 120x) work well when looking for targets like galaxies. To scrutinize details on the Moon and planets, high power (150x to 200x) is essential. To find out what power an eyepiece will provide for your scope, divide the eyepiece's focal length (usually printed on the barrel) into the telescope's focal length. As a rule of thumb, the highest power usable works out to 50 to 60x per inch of aperture.

Most imported economy telescopes come with poor-quality, 0.965-inch barrel-diameter eyepieces. Typically these eyepieces suffer from tunnel-like fields and false color. Of better caliber are eyepieces with 1.25-inch barrel diameters. In that category you'll find good-quality Kellner, Modified Achromatic, and Orthoscopic designs. One step better in performance (and higher in price) are the Plössls. These eyepieces provide a 40° to 50° field of view. Wide-angle, 2-inch barrel eyepieces provide fields of up to 84°, but tend to cost hundreds of dollars.





ASTRONOMY BOOKS FOR Kids

Giving a child one of these books might be just the thing to trigger a lifetime interest in the stars and planets.

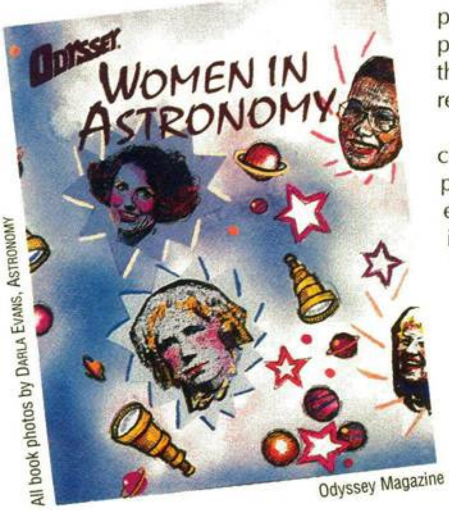
by David Bruning

Some say the days of books are near an end, with CD-ROMs and computer multimedia programs hard upon us. But I have yet to see a child curl up with a good CD-ROM on a rainy day. Books remain a powerful visual medium that engages kids' minds and not just their fingers as a video game does.

A great picture of Saturn and its rings can turn a kid onto astronomy faster than you can say Enceladus. And from a book the child can learn that Enceladus is the ninth satellite of the Ringed Planet. Other books unleash kids' imaginations, letting them journey to distant worlds with their minds. After all, science isn't a pile of facts but a way of exploring nature.

Compiling a comprehensive list of astronomy books for kids is impossible: There are just too many. So consider the following list just a sampling of the rich collection of books you can find on your local bookseller's shelves. The listing doesn't contain addresses for most of the publishers because your book dealer can order a book knowing the title, author's name, and the International Standard Book Number. Several publishers sell directly to the public, so we list their addresses here.

The first item on the list isn't a book at all. It's a great magazine about astronomy written for kids ages 8 to 14 — ***Odyssey*** (7 School Street, Peterborough, NH 03458; a year's subscription of ten issues costs $22.95; schools can get a discounted rate of $14.95 per subscription for five or more subscriptions; each issue has 48 pages). The March 1994 issue contained five feature articles about famous and influential women in astronomy from Maria Mitchell (1818-1889) to Vera Rubin, winner of the 1993 National Medal of Science for her contributions to the understanding of galaxies and dark matter. Regular departments show where to find the planets in the sky, provide a mind-boggler puzzle, review books and videos, and suggest an observing activity.

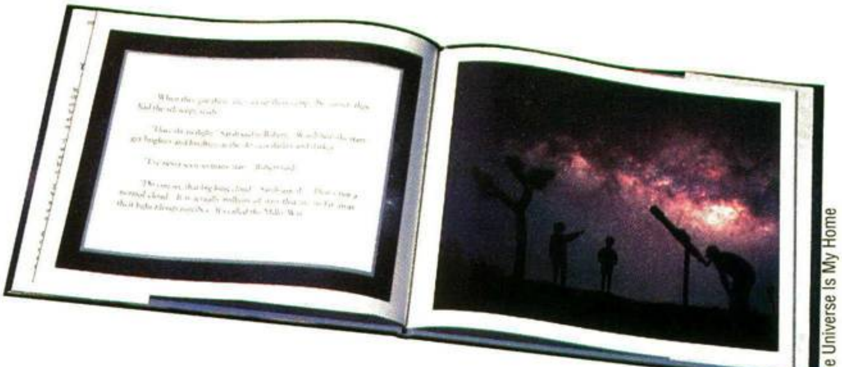


Odyssey Magazine

All book photos by Darla Evans, Astronomy

The list continues with three items for young readers. The remaining books will appeal to kids ages 7 and up; grouped by theme, the books describe do-it-yourself activities that demonstrate astronomical ideas, the planets and solar system, the universe, and viewing the night sky. Think about buying a book just a little more advanced than the child's present reading level. That way the child can grow into the book as interest and knowledge about astronomy increases.

Young children will like ***The Universe Is My Home***, an adventure story set in space. Two alien beings take Sarah and Robert on a tour that ends at the aliens' home planet in another galaxy. The book features some astrophotography by Bill and Sally Fletcher, who are also the book's authors (Science and Art Publishing, 24861 Rotunde Mesa, Malibu, CA 90265, 1993, 32 pages, $14.95, ISBN 0-963622-0-2).



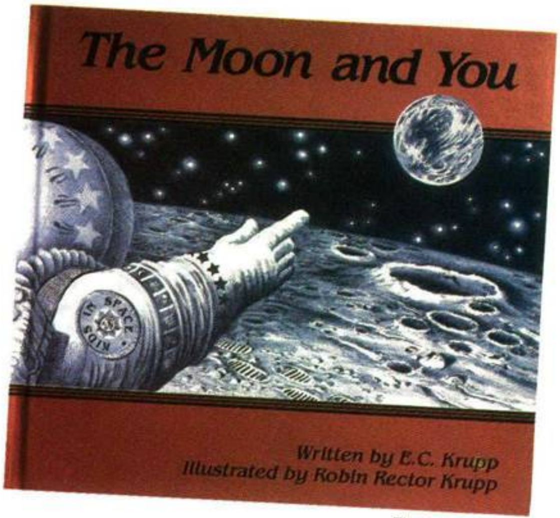
The Universe Is My Home

Parents can read ***The Moon and You*** to five- and six-year-olds; older children can peruse this book on their own (Macmillan, 1993, 48 pages, $13.95, ISBN 0-02-751142-1). Written by E. C. Krupp and illustrated by Robin Rector Krupp, it describes what it would be like to visit the airless satellite of Earth and how ancient cultures viewed the Moon. The Krupps tell — and show — how phases occur and how simple observations of the phases by ancient astronomers led to the present-day calendar. A discussion of figures seen on the Moon's surface — rabbits, a frog, a man, women — leads to another on the craters and mare regions that cover the surface and give rise to the perceived shapes.

Words in a book won't appeal to many young children but songs and activities do. Tonja Evetts Weimar has written ***Space Songs for Children*** (Pearce-Evetts Publishing, P.O. Box 79117, Pittsburgh, PA 15216, 1993, $13.95, ISBN 0-936823-11-9). A 101-page book written for parents and teachers accompanies the tape and provides activities related to each of the 12 songs.

Hands-on activities interest older children as well. Robert W. Wood presents 39 easy astronomy experiments aimed for ages 8 to 13 in ***Science for Kids*** (Tab Books, 1991, 140 pages, $9.95, ISBN 0-8306-3597-1). Activities include measuring angles in the sky, determining the diameter of the Moon, finding north by the Sun, learning why stars twinkle, building a simple telescope, discovering how gravity causes objects to fall, and photographing star trails.

Noted astronomy educator Dennis Schatz presents some of his activities for children 10 and up in the ***Astronomy Activity Book*** (Little Simon, Simon and Schuster, 1991, 48 pages, $6.95, ISBN 0-671-70449-4). Schatz's activities engage the brain as well as the hand and promote learning of basic astronomical concepts. An example is modeling the Moon's phases, which uses a ball and lamp to study the motion of the Moon and how that creates lunar phases as seen from Earth. Others of the dozen activities include hunting planets, building a Sun compass, making a star finder (or planisphere), creating your own constellations, projecting an image of the Sun using binoculars, and exploring how eclipses occur.



The Moon and You

Kids of all ages ask lots of questions, such as How big is Jupiter? How many satellites does Neptune have? Will the Sun die? They can find their own answers in some of the following books.

Patricia Barnes-Svarney takes young readers on a tour of the planets in the ***Traveler's Guide to the Solar System*** (Sterling Publishing Co., 1993, 80 pages, $14.95, ISBN

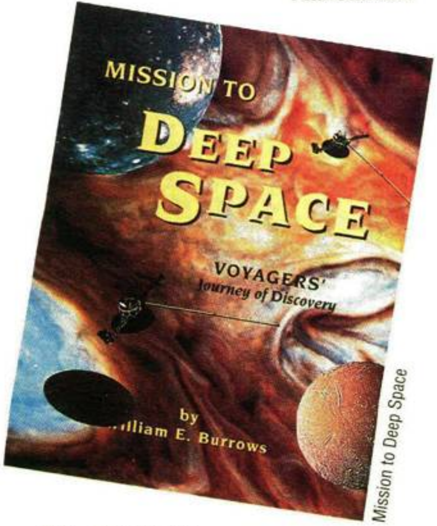
Chapter Six
THE RINGS AND MOONS OF SATURN

Traveler's Guide to the Solar System

0-8069-8672-7). Starting with Mercury, Barnes-Svarney describes what astronomers know about each planet and what questions linger, such as where did the water on Mars go after it formed the huge channels seen on the Red Planet's surface? Color images of each planet taken by NASA spacecraft provide a picture album of the planetary tour.

Mission to Deep Space (Scientific American Books for Young Readers, W. H. Freeman and Company, 1993, 80 pages, $17.95, ISBN 0-7167-6500-4) by William E. Burrows concentrates on the two Voyager spacecraft and their flybys of four of the outer planets of the solar system: Jupiter, Saturn, Uranus, and Neptune. For each of the planets, Burrows indicates what astronomers knew about the distant world before the Voyager mission and what they learned from the flyby. One of the most dramatic images is the family portrait taken of the entire solar system by Voyager 1 when it was several billion miles away from the planets. A glossary helps readers with some astronomical terms.

Another book detailing the solar system is Barbara Brenner's ***Planetarium*** (Bank Street Museum Book, Bantam Books, 1993, 48 pages, $16, ISBN 0-553-07619-1). Illustrated by Ron Miller, this book takes you on a trip to the museum portion of a planetarium and presents "exhibits" about each of the planets and the Sun. A "Hall of the Past" introduces children to important astronomers of previous eras and a "Hall of the Future" examines what it might be like to colonize the Moon. A poster about lunar exploration accompanies this book intended for ages 7 to 10.



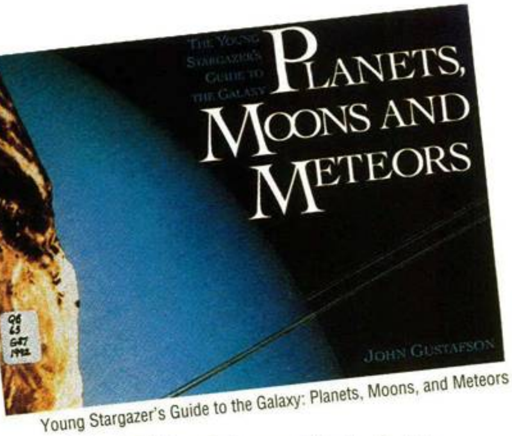
Mission to Deep Space

John Gustafson includes activities along with descriptions of the planets in ***The Young Stargazer's Guide to the Galaxy: Planets, Moons, and Meteors*** (Julian Messner, 1992, 64 pages, $6.95, ISBN 0-671-72535-1). Activities include studying the greenhouse effect by measuring the temperature inside a car with closed windows, making craters by dropping marbles into flour, watching the moons of Jupiter through binoculars, collecting micrometeorites from rain water, and making a comet from dry ice and water.

Older kids will want more detailed information about the planets. They'll find it in the ***Peterson First Guides: Solar System*** written by Jay M. Pasachoff, (Houghton Mifflin Company, 1990, 128 pages, $4.95, ISBN 0-395-52451-2). Pasachoff shows both ground-based and spacecraft views of the planets, showing how astronomers can learn by sending spacecraft to take close-up pictures of the planets. He provides maps that identify features on the Moon and sky charts (drawn by Wil Tirion) that help locate planets in the sky until the year 2000.

Atlases (these books should perhaps be more appropriately called encyclopedias) provide information about the entire universe, including stars and galaxies as well as the planets. They are usually large books, typically over 12 inches in height. One example is Ian Ridpath's ***Atlas of Stars and Planets*** (Facts on File, Inc., 1993, 80 pages, $16.95, ISBN 0-8160-2926-1). Ridpath devotes the first 50 pages to the solar system, providing details about the planets, the Moon, comets, and asteroids. The remaining pages discuss stellar life cycles, supernovae, star clusters, the Milky Way Galaxy, other galaxies, and the origin of the universe. A set of equatorial star maps shows constellation figures and labels bright stars but unfortunately does not portray how the stars actually appear in the night sky.

Readers ages 7 to 10 wanting information on space exploration as well as the planets, stars, and galaxies should look at


THE YOUNG STARGAZER'S GUIDE TO THE GALAXY
PLANETS, MOONS AND METEORS
JOHN GUSTAFSON

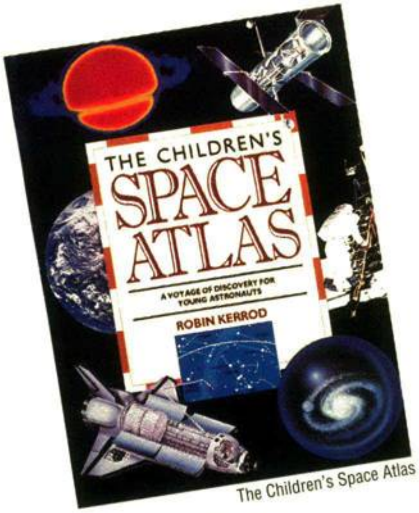
Young Stargazer's Guide to the Galaxy: Planets, Moons, and Meteors

The Children's Space Atlas by Robin Kerrod (The Millbrook Press, 1992, 96 pages, $18.95, ISBN 1-56294-100-3). A 16-page section explains how telescopes work, describes satellite orbits, discusses the need for satellite observatories, recounts the Apollo program to visit the Moon, and examines the future of spaceflight. Sky maps show the constellations seen in winter and summer.

Peterson First Guides
SOLAR SYSTEM
A simplified field guide to the planets, the sun, comets, and other objects in our solar system
Jay M. Pasachoff
Illustrated by Wil Tirion

Peterson First Guides: Astronomy and Solar System

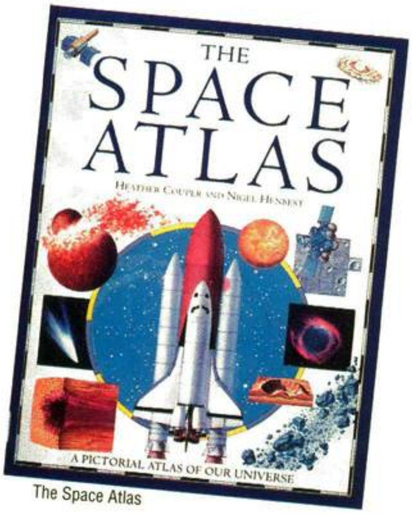
Heather Couper and Nigel Henbest have produced an atlas that will appeal to slightly older children (ages 8 to 12). ***The Space Atlas*** (Gulliver Books, 1992, 64 pages, $16.95, ISBN



The Children's Space Atlas

0-15-200598-6) provides more detail on how rockets place payloads into orbit, what living on a space station would be like, and how astronauts and scientists explored the Moon. Cutaway drawings show the structure of planets while pie charts reveal the constituent elements in their atmospheres. Even the illustrations of Saturn's rings give additional details like the designations of the various rings and the location of the satellite orbits inside the rings. Several illustrations show the Sun's location in the local stellar neighborhood and the Milky Way Galaxy's position in the Local Group of galaxies.

A pocket guide to the heavens is handy for trips and taking outdoors while observing. Jay M. Pasachoff's ***Peterson First Guides: Astronomy*** (Houghton Mifflin Company, 1988, 128 pages, $4.95, ISBN 0-395-46790-X) fits in a jacket pocket, has a set of monthly sky maps produced by Wil Tirion, and provides lots of information about the planets, stars, and galaxies. A series of 12 illustrations portray the mythical figures for which the constellations are named and have text that explain the folklore behind the figure and describe some of the deep-sky objects visible in the region with binoculars.


THE
SPACE
ATLAS
HEATHER COUPER AND NIGEL HENBEST
A PICTORIAL ATLAS OF OUR UNIVERSE

The Space Atlas

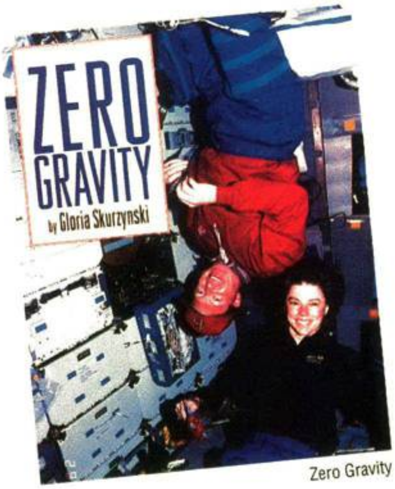
A good book related to space exploration is Gloria Skurzynski's ***Zero Gravity*** (Bradbury Press, 1994, 32 pages, ISBN 0-02-782925-1). It explains why satellites and the Moon orbit Earth and how the motion of a space shuttle in its orbit around Earth creates zero gravity. Pictures of life onboard the shuttle demonstrate how zero gravity affects astronauts as they work, eat, and sleep.

Reading about astronomy and space is fine, but children should also look up and become friends with the stars. To help them do that, they need a guidebook. I.M. Levitt and Roy K. Marshall provide a set of monthly sky charts in their ***Star Maps for Beginners*** (Fireside, 1992, 64 pages, $10, ISBN 0-671-79187-7). Accompanying text delves into the mythology of major constellations and describes how to navigate between the bright stars in prominent constellations. Several tables indicate when to look for meteors and in which constellation to look for Venus, Mars, Jupiter, and Saturn through 1997.

Older children may wish to explore the deep-sky objects mentioned in Richard Berry's ***Discover the Stars*** (Harmony Books, 1987, 119 pages, $10.95, ISBN 0-517-56529-3). A set of 23 star charts help locate the objects visible in small telescopes.

Two other items complete this gift list for kids. A planisphere, or star finder, is an indispensable aid for finding and identifying stars and constellations at any hour of the night, on any day of the year. Kalmbach Publishing [(800) 533-6644] sells ***Miller's Planisphere*** in two versions, one is for observers around 30° north latitude (southern United States) and the other for observers near 40° north latitude (northern United States). Both are 10.5 inches in diameter and are made from waterproof plastic.

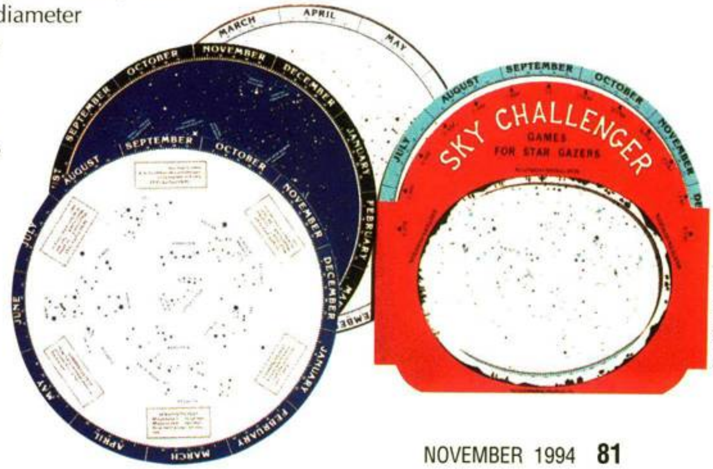
A novel planisphere called the ***Sky Challenger*** is available from the Lawrence Hall of Science (University of California, Berkeley, CA 94720, $7.95.) Six interchangeable disks show the night sky in different ways. For example, one shows the sky with only bright stars and prominent constellations marked. Another shows the locations of deep-sky objects visible through binoculars. A third shows the constellations envisioned by Native Americans. Yet another lets users draw their own constellation figures.



Zero Gravity

The other item that will appeal to kids is a poster to decorate their room. The Astronomical Society of the Pacific [390 Ashton Avenue, San Francisco, CA 94112, (415) 337-2624] sells two dozen astronomical posters for $9.95 each. The subjects include planets, comets, meteorites, galaxies, supernova remnants, bright nebulae, cosmic catastrophes, planet Earth, and the solar system as a whole.

Young people don't have to try to read the books written for adults, struggling with words they don't understand and illustrations they can't comprehend. Give them one of the books mentioned here and watch their eyes light up as they discover the immense cosmos waiting for them. □



Sky Challenger

Reaching for the Corona

Up to four minutes of totality await those who venture to South America for November's solar eclipse.

by Joel K. Harris

On November 3, for the third time in less than four years, the Moon's shadow will cut across part of South America. With eclipse chasers' appetites whetted by last May's annular eclipse, seen by thousands of people in North America, this total eclipse promises to be one of the most sought-after astronomical events since the great eclipse of July 1991.

The Moon's shadow first touches the continent on the southern coast of Peru. From there it heads southeast, passing over parts of Chile, Bolivia, Paraguay, Argentina, and finally Brazil. The shadow then departs land and tracks across the South Atlantic Ocean, finally leaving Earth's surface far off the tip of South Africa (see "Return to Darkness," November 1993).

Besides providing a slightly longer than average totality, this eclipse offers favorable weather prospects along much of the path of totality. The regions of Tacna in Peru, Putre in Chile, and the Altiplano (high plateau) in Bolivia, and from near Asunción, Paraguay, to western Brazil, all share a minimum 60 percent chance of clear skies on eclipse day. The best among these is the Altiplano, where statistical data indicate a better than 80 percent probability of good weather.

But remember the old adage of the meteorologist: Climate is what you expect, but weather is what you get. Just because statistics indicate that historically the weather looks promising for a particular place at a particular time of year, weather on any one day at any one place is a crapshoot. Ask anyone who traveled to Hawaii for the July 1991 eclipse or who observed near the centerline on the eastern side of the Baja Peninsula in Mexico during that eclipse. Clouds can form suddenly and with no warning. Eclipse chasing comes with no guarantees.

Totality aside, eclipse observers will be drawn to the Southern Hemisphere by such additional enticements as visits to the ancient Incan ruins at Machu Picchu, the mysterious culture of the Bolivian Kallawaya peoples in the Lake Titicaca area, star parties under dark southern skies, and the prospect of seeing totality at Iguaçu Falls (or Iguazú Falls, for those who prefer Spanish to Portuguese) — South America's answer to North America's Niagara Falls.

In preparing for this eclipse, however, eclipse observers need to be particularly aware of a number of unusual situations they may encounter in traveling to the countries along the eclipse track.

Reaching the Heights

For many visitors, the most challenging aspect to this eclipse will be coping with the significant, if not downright extreme, altitudes they will encounter on excursions going to the Altiplano of Bolivia, the mountains of Peru, or the high passes of northeastern Chile.

Most major expeditions going to these venues will spend the majority of their trips at heights at or above 9,000 feet and in some cases climb to 13,000 or more feet to see totality! Viewing totality from such altitudes enhances the visibility of the corona because Earth's atmosphere scatters less of this opalescent light. But at these altitudes, many travelers will suffer minor, or possibly major, effects from the thin air.

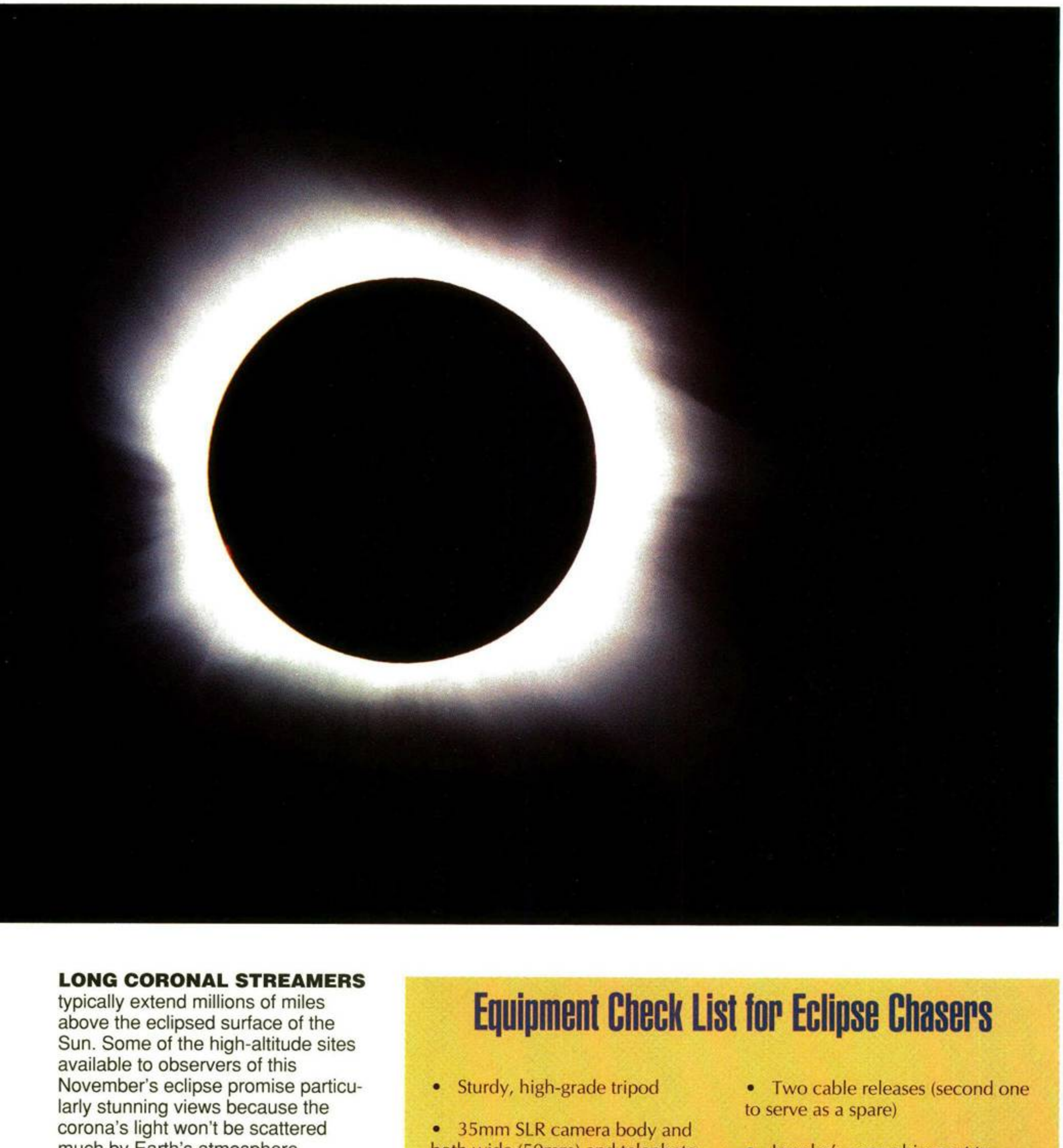
Some expeditions will give participants several days to acclimate before ascending to the maximum elevation encountered on their journey. Many others, however, plan direct ascents from near sea level to their peak altitudes in a matter of hours. People on such tours need to take several precautions.

First, do not overexert yourself for the first day or two. This doesn't mean you need to lie in bed for days after you arrive. Just go easy and don't overdo things.

Second, do not drink any alcohol upon arriving at high altitude. Even if you feel on top of the world, consuming alcohol after a quick ascent can bring on a severe headache, lethargy, and other symptoms of acute mountain sickness. Besides, a hangover at high elevation is not a pleasant experience.

Third, eat only low-fat food and only in small portions. Consuming large, fat-laden meals invites the effects of mountain sickness: disturbed sleep, excessive gas, and "air hunger" (brought on because the blood needed to oxygenate your body remains in the stomach and intestines longer than at sea level).

I highly suggest readers acquire an excellent little book on the effects of altitude, published by the American Alpine Club of Golden, Colorado, *Mountain Sickness — Prevention, Recognition, and Treatment,* by Peter Hackett, M.D. You can purchase it from the AAC by calling (303) 384-



Andreas Gada

LONG CORONAL STREAMERS typically extend millions of miles above the eclipsed surface of the Sun. Some of the high-altitude sites available to observers of this November's eclipse promise particularly stunning views because the corona's light won't be scattered much by Earth's atmosphere.

0110, or faxing (303) 384-0111. The price per copy is $6.50 plus $3.50 for shipping and handling.

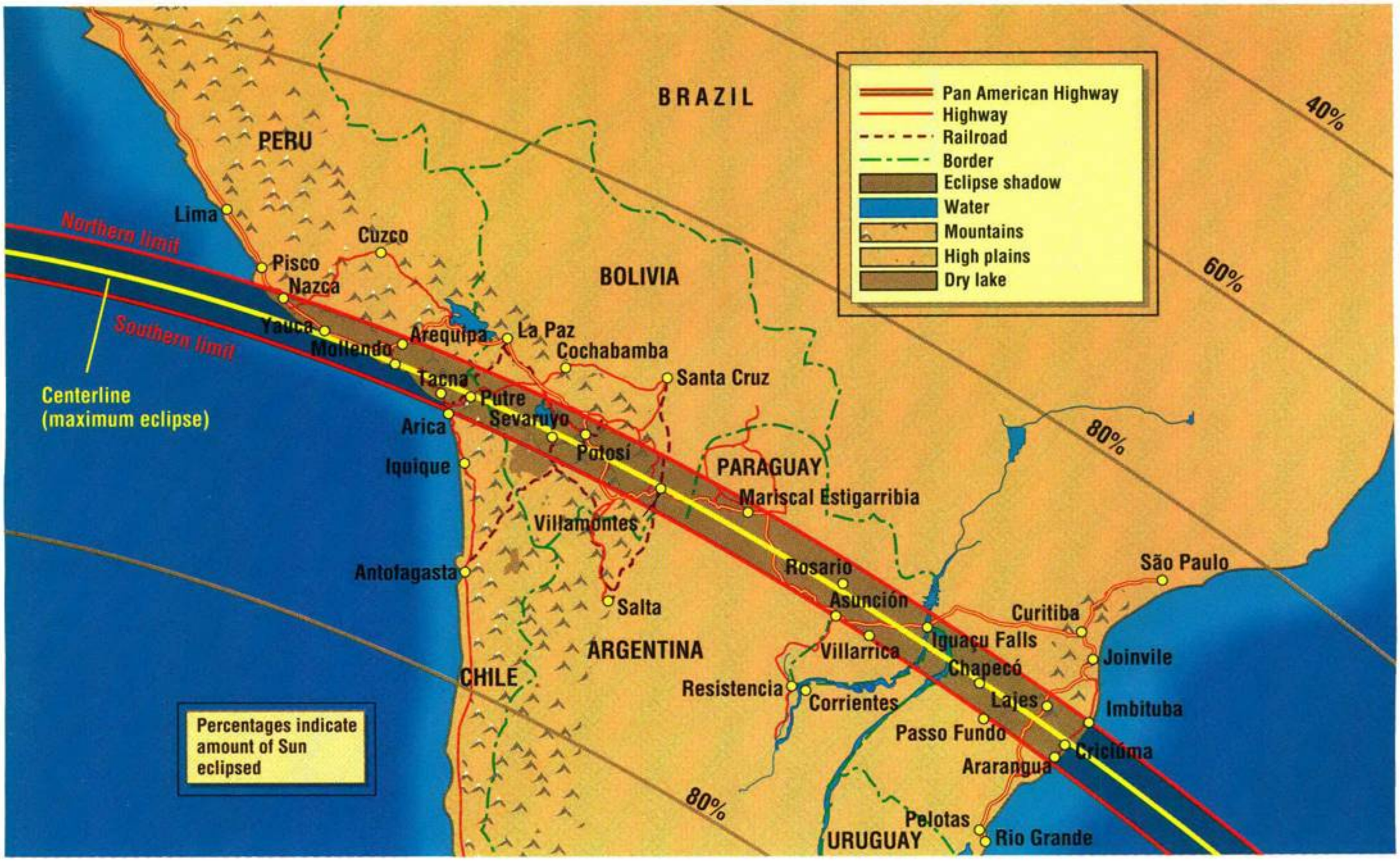
No one can predict accurately who will suffer from the effects of high altitude. The triathlete is just as susceptible to mountain sickness as the couch potato. Also, it's impossible to self-diagnose the effects of altitude. Traveling companions or an M.D. on your expedition should evaluate your condition.

Equipment Check List for Eclipse Chasers

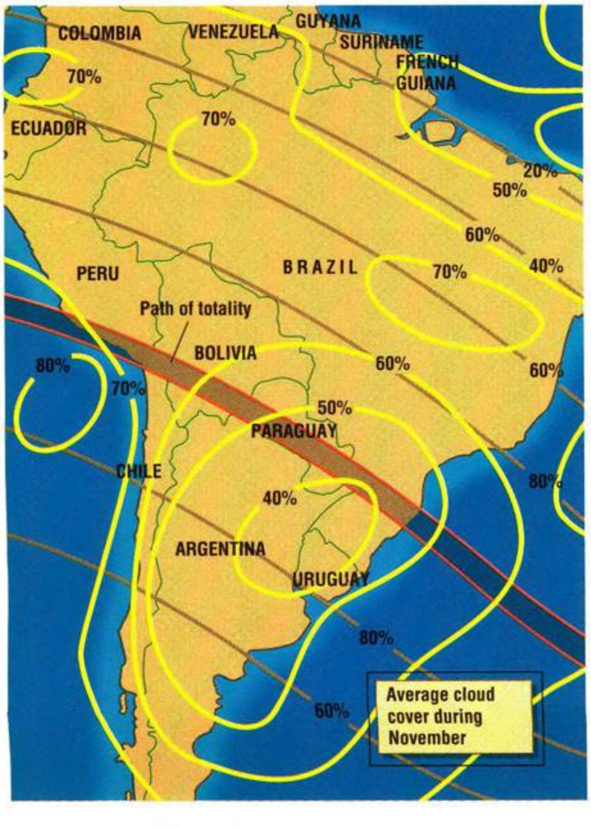
- Sturdy, high-grade tripod
- 35mm SLR camera body and both wide (50mm) and telephoto (200mm or more) interchangeable lenses
- Extra camera batteries
- At least four rolls of 35mm photographic film, using speeds of ISO 100, 200, and 400 to handle variable sky conditions
- Drafting or photographic tape to fix focus and aperture rings to desired settings and prevent slippage
- Two cable releases (second one to serve as a spare)
- Jeweler's screwdriver set to tighten loose camera set screws
- Sunscreen lotion with a minimum SPF of 15 because skin burns faster at high altitudes
- Suitable clothing for near-freezing conditions, but layerable for daytime temperatures
- One hat for daytime Sun protection and another to prevent heat loss while observing at night

WHERE TO SEE THE ECLIPSE

THE MOON'S SHADOW SLICES through central South America on November 3, bringing good prospects for clear weather along much of its path.



BRAZIL
PERU
BOLIVIA
PARAGUAY
ARGENTINA
CHILE
URUGUAY
Northern limit
Southern limit
Centerline (maximum eclipse)
Lima
Pisco
Nazca
Cuzco
Yauca
Mollendo
Arequipa
La Paz
Cochabamba
Santa Cruz
Tacna
Putre
Sevaruyo
Arica
Potosí
Iquique
Mariscal Estigarribia
Villamontes
Antofagasta
Salta
Rosario
Asunción
Villarrica
Resistencia
Corrientes
Iguaçu Falls
Curitiba
Chapecó
Lajes
Passo Fundo
Araranguá
Criciúma
Joinvile
Imbituba
São Paulo
Pelotas
Rio Grande
40%
60%
80%
80%
Pan American Highway
Highway
Railroad
Border
Eclipse shadow
Water
Mountains
High plains
Dry lake
Percentages indicate amount of Sun eclipsed



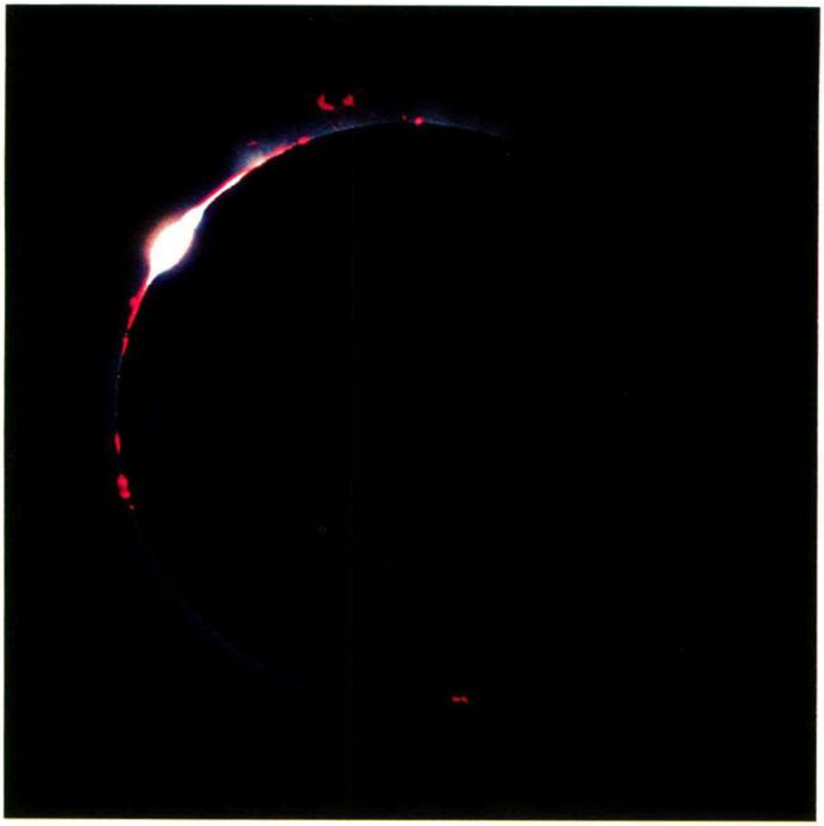
COLOMBIA
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
ECUADOR
PERU
BRAZIL
BOLIVIA
PARAGUAY
CHILE
ARGENTINA
URUGUAY
Path of totality
70%
70%
20%
50%
60%
70%
40%
80%
70%
60%
50%
60%
40%
80%
80%
60%
Average cloud cover during November

Location	Local Time at Mid-Eclipse	Altitude of Sun	Azimuth of Sun	Duration of Totality	Likelihood of Clear Weather
Yauca, Peru	7:13:22	26°	100°	2m39s	40%
Arequipa, Peru	7:16:06	29°	98°	0m58s	70%
Mollendo, Peru	7:16:39	29°	98°	2m51s	30%
Tacna, Peru	7:19:09	31°	97°	2m53s	40%
Arica, Chile	8:19:43	32°	97°	1m51s	40%
Putre, Chile	8:19:52	32°	97°	2m59s	80%
Sevaruyo, Bolivia	8:23:38	36°	95°	3m07s	80%
Potosí, Bolivia	8:25:01	37°	94°	2m43s	80%
Centerline southeast of Potosí	8:26:41	38°	94°	3m14s	80%
Villamontes, Bolivia	8:29:39	40°	92°	3m18s	40%
Mariscal Estigarribia, Paraguay	8:33:59	44°	90°	2m22s	60%
Rosario, Paraguay	8:42:14	49°	85°	3m35s	60%
Asunción, Paraguay	8:42:43	49°	84°	0m41s	60%
Villarrica, Paraguay	8:45:09	50°	83°	2m14s	60%
Iguaçu Falls, Brazil	9:47:26	52°	81°	3m26s	60%
Chapecó, Brazil	9:52:55	55°	77°	3m52s	60%
Lajes, Brazil	9:57:41	58°	73°	3m38s	50%
Criciúma, Brazil	10:00:37	59°	70°	4m02s	50%

The weather statistics above are based on detailed satellite images in the weeks around the eclipse time during 1991 and 1992. The average cloud cover statistics on the map at left show only large-scale patterns compiled over a 10-year period and overstate the cloudiness in the high country of western South America.

ASTRONOMY: Both illustrations by Lee Vande Visse

BAILY'S BEADS MARK the final seconds of an eclipse's partial phase and signal the beginning of totality — up to four minutes' worth during this eclipse.



Hal Jandorf

What to Take

As mentioned above, travelers to South America should avoid overexertion to lessen their chances of getting acute mountain sickness. The easiest way to do this is to leave all the heavy equipment at home. As any veteran eclipse chaser will tell you, traveling light and keeping things simple is always the best way to go.

In most cases, people will be traveling thousands of miles and taking several flights on connecting airlines to get to the eclipse in South America. Bringing along every conceivable kind of telescopic and photographic gizmo just doesn't make sense. The more complex you make the setup, the greater the possibility of losing, damaging, or just plain forgetting some critical part. Who hasn't started driving to a local star party and seriously considered turning around after realizing that a critical tripod, camera adapter, or favorite eyepiece was sitting back home? Only in South America, home may lie 12 or more hours away by jet aircraft, and you'll be out of luck.

A sturdy tripod, a 35mm SLR camera with a high quality lens of medium to long focal length, a couple of cable releases, and ample film will serve you quite well this November. If you feel you must have a telescope, stick with a small, easily transportable model or even a spotting scope. Besides, the best views of totality come with the naked eye or moderate magnification like that provided by binoculars or a small telescope.

Before packing equipment, compare your checklist with the suggested packing list shown on page 83. Take special note of the spare camera batteries, jeweler's screwdrivers, and extra cable releases. Items like these are nearly impossible to find outside the major cities in South America. And even when you can find them, they often cost two or three times their price at home because they are scarce and the exchange rate does not favor those with U.S. currency.

When deciding what clothes to take along, expect to encounter both warm and cool conditions. Even though it is late spring in the Southern Hemisphere, many people will seize the opportunity to explore the southern sky at night, when temperatures will be cool if not downright cold. Particularly on the Altiplano and in the high mountains of Peru and Chile, it frequently drops to freezing or below during the night. Bring a heavy sweater, long underwear, and a warm hat to guarantee that eclipse morning will not find you a human popsicle, having frozen solid during the night of November 2.

Don't prepare for a polar expedition, but take clothing that can be worn in layers. You can always peel off some of those layers if things get toasty later on.

As for the rest of your wardrobe, most places on the continent do not require fancy duds. South America is a casual place. But some areas do require men and women to wear long pants, particularly in churches or the more stylish restaurants or clubs. Unless you plan on going to a swanky nightclub or casino, however, your three-piece suit or cocktail dress can remain at home.

Some Final Tips

Wherever you travel for this eclipse, be smart. Take only those items you must have with you. Don't come laden with a dozen suitcases or carry-on items. Taking all that stuff is no picnic, and carrying it around gets old quickly.

Also be sure you have the proper travel documents for the countries you'll be going to. If you aren't sure what's needed, call your tour operator and ask. If you are going independently, query your professional travel agent. Be sure you have copies of any vital medication prescriptions, in case your luggage takes a side vacation to Suriname instead of arriving with you in Peru.

If you venture out at night in a big city, go with friends. Don't take unnecessary risks by walking through seedy or poorly lit areas. Ask your tour escort or the hotel concierge if there are areas to avoid visiting at night. But don't be intimidated — see what there is to see.

Above all, be patient. Travel in foreign lands is rarely without delays or small inconveniences. Take it easy, especially if your plane is late, the bus gets a flat tire, or the hotel takes more time to check you in than the Holiday Inn back home. This is not the United States or Europe. It's all part of the reason people chase eclipses — to visit places unlike home and view the drama of totality in an exotic land. ☐

Joel K. Harris is president and founder of Twilight Tours, Inc., an astronomical travel company based in Burbank, California. This month he will lead his firm's fifth major eclipse expedition. He is coauthor, along with the ASTRONOMY *editor Richard Talcott, of* Chasing the Shadow: An Observer's Guide to Eclipses *(Kalmbach, 1994).*

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— Don J. Colton
Midvale, Utah

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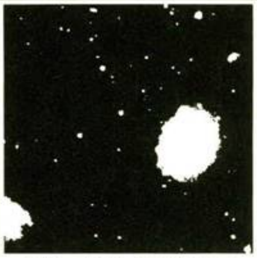

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Watching the Comet Go Boom

"I seriously doubt that amateur astronomers will see anything — I recommend they look at Jupiter during an impact as a novelty and go inside to watch CNN to see what's really happening on Jupiter." To nearly everyone's delight, comet codiscoverer David Levy's warning proved groundless. (No one could have been happier about that than Levy himself.)

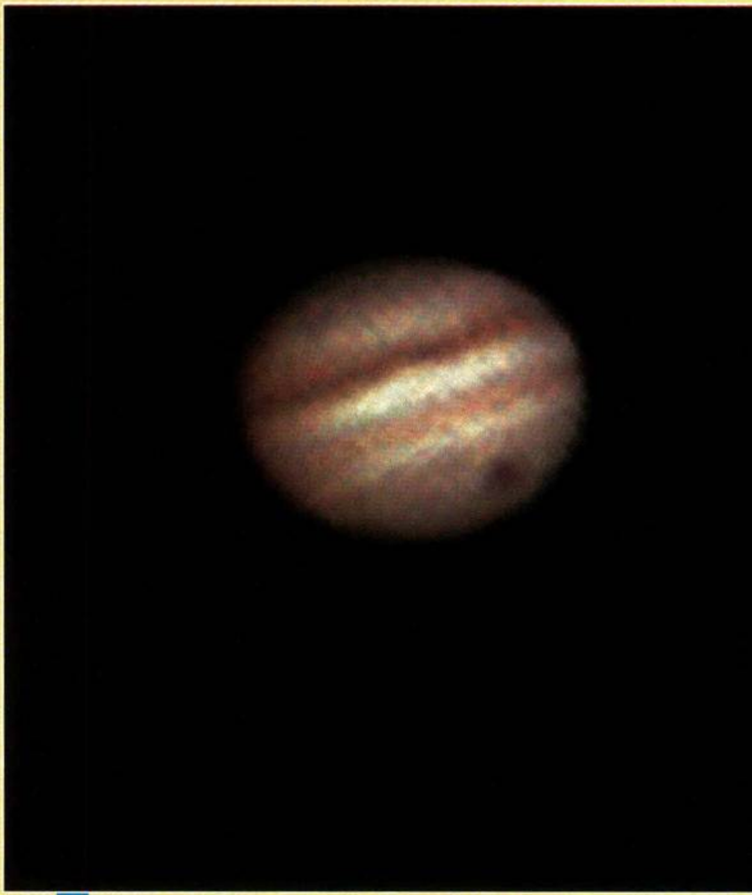
Not only did backyard astronomers see many of the comet's impact sites as large, obvious "black eyes" in Jupiter's clouds, they also could see the biggest scars with telescopes as small as two inches aperture. While the comet outperformed the expectations of professional astronomers, it also created the most sensational week in backyard observing in recent memory, erasing the disappointing performances of Comets Kohoutek (visible in 1973/4) and Halley (1985/6), both relative duds.

During the weekend, reports began to flood the electronic airwaves of television and the Internet, making it clear that amateur astronomers everywhere were seeing Jupiter's bruises. "This is unbelievable," said California amateur Wayne Johnson on July 18. "We have an event in observational astronomy that's outperforming everyone's highest hopes." Johnson reported seeing multiple spots with his 14.5-inch scope at 150x and the 22-inch telescope of the Orange County Astronomers in Anza, California. The resolution of the view was good enough, in fact, to let Johnson measure the separation of spots E and F and estimate it at 5".

After being told that well-equipped amateurs "might" see the largest sites, California observer John Sanford replied on July 18, "Are they kidding? I imaged them last night with a 12-inch Ritchey-Chrétien scope under lousy seeing." Frank Reed spotted the impact site made by fragment A from downtown Chicago using his 10-inch SCT. "It was a well-defined, black spot," said he, "visible from my own rooftop." Out in California, meanwhile, Ralph Merletti was discovering that the growing number of impact sites could be seen in a 3-inch telescope. And then came the G spot.

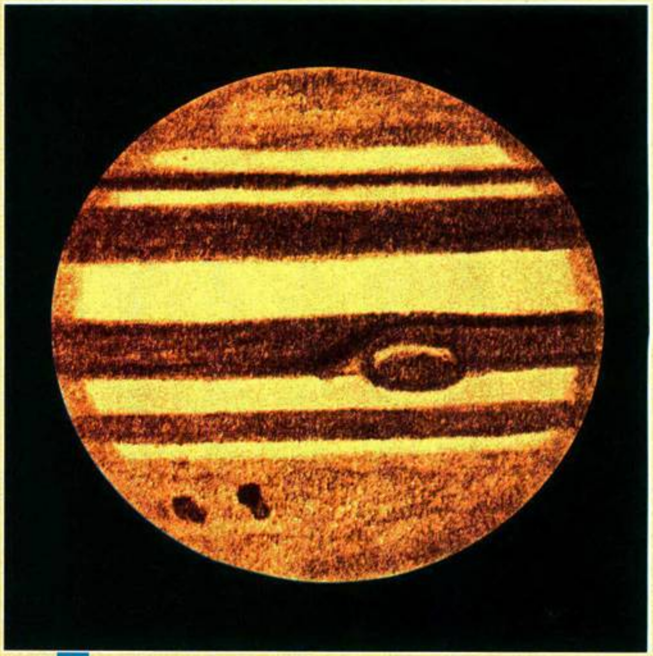
The black gash in Jupiter's pearly-white cloudtops created by fragment G, which formed early on the morning of July 18, turned out to be the largest and most easily visible spot. Said California observer Russell Sipe, "The great G spot is the most prominent feature on Jupiter — maybe I'm hallucinating!" Tim Gieseler of Santa Cruz, California, spent several hours with a 4-inch refractor, an 8-inch SCT, and a 10-inch reflector looking at the great spot. "During twilight on July 19 the spot was visible as a large smudge near the planet's limb," he says. "It appeared on the order of the size of the Great Red Spot. It was so clear, so distinctly visible, despite relatively poor seeing. I can hardly wait to see the photos." Forthcoming issues will bring them to you, along with observing reports and sketches. Stay tuned. ☐

Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Label each photo with name, address, and social security number. You may send written reports via Internet to 72000.2704@CompuServe.com



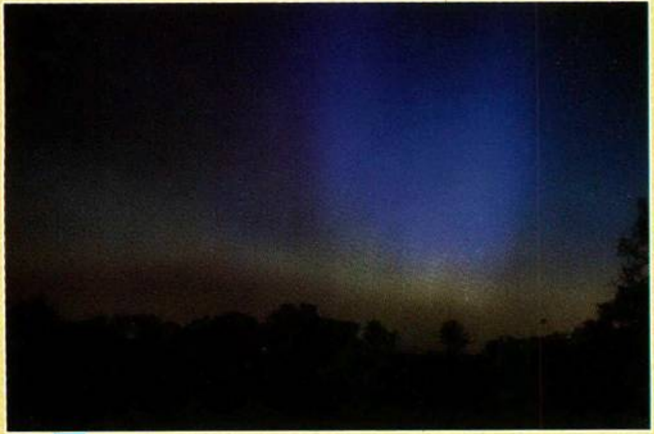
Jupiter's G Spot

by Adrian Catterall
(12-inch SCT at f/20, ST-6 CCD camera, taken on July 18, 1994)



Bruises Mark Jupiter's Cloudtops

Sketch by Jose Olivarez
(10-inch f/7 reflector at 195x on July 18, 1994)



A Violet Aurora Paints the Sky

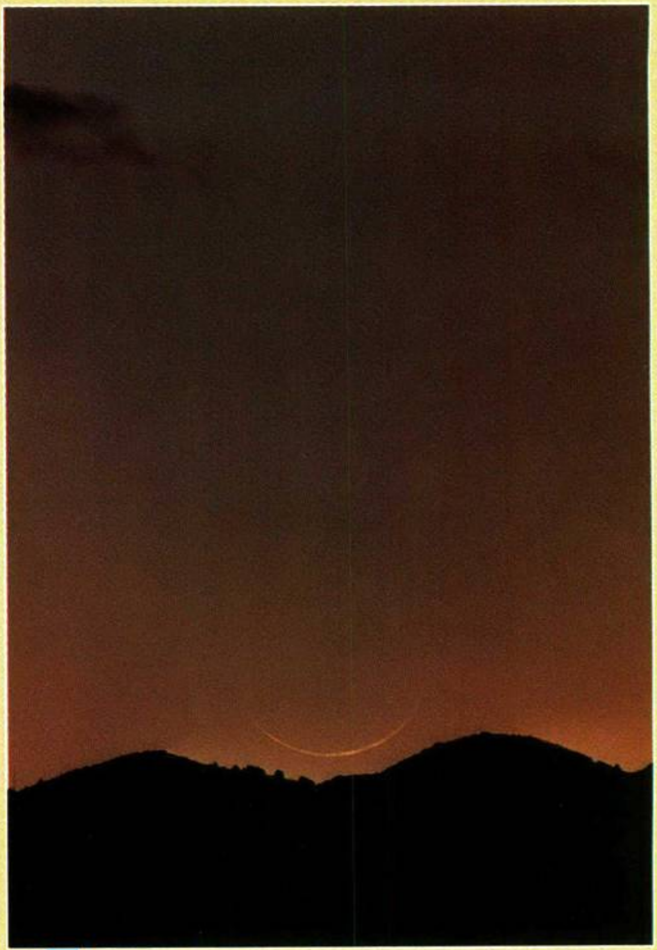
by Jeff Copland
(28mm lens, 400 ISO film, 100-second exposure on April 16, 1994, from Belvidere, Illinois)

Comet McNaught-Russell

by Bob Yen
(8-inch f/1.5 Schmidt camera, hypersensitized Tech Pan film, 4-minute exposure on April 4, 1994)

Comet Takamizawa-Levy

by Gerald Rhemann
(6.7-inch Schmidt camera, hypersensitized Tech Pan film, 7-minute exposure on June 8, 1994)



A Young Moon Peeks Out

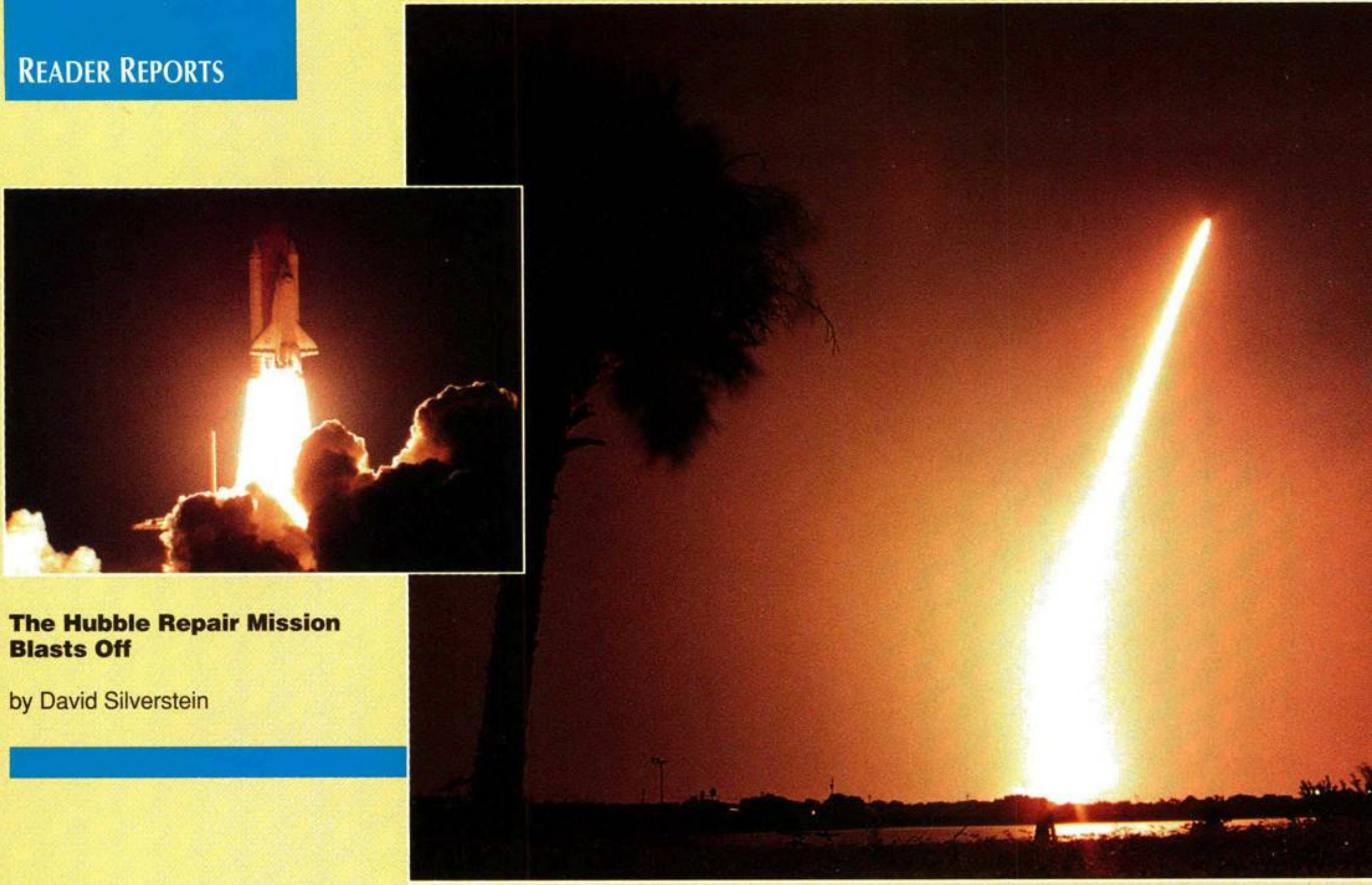
by Peter Ledlie
(4-inch f/8 refractor, Fujicolor 100 ISO film, 1-second exposure on April 11, 1994)

A DUSTY COCOON IN SPACE

The Cocoon Nebula in Cygnus (IC 5146) is a challenging object for visual observers armed with backyard scopes. Characterized by low surface brightness, the wispy cloud of gas requires an 8-inch or larger scope to detect at all. Photographing the elusive nebula was the objective for Ken Blankenship and Dennis Batis, whose color portrait (opposite page) wins this month's $100 Best Astrophoto award.

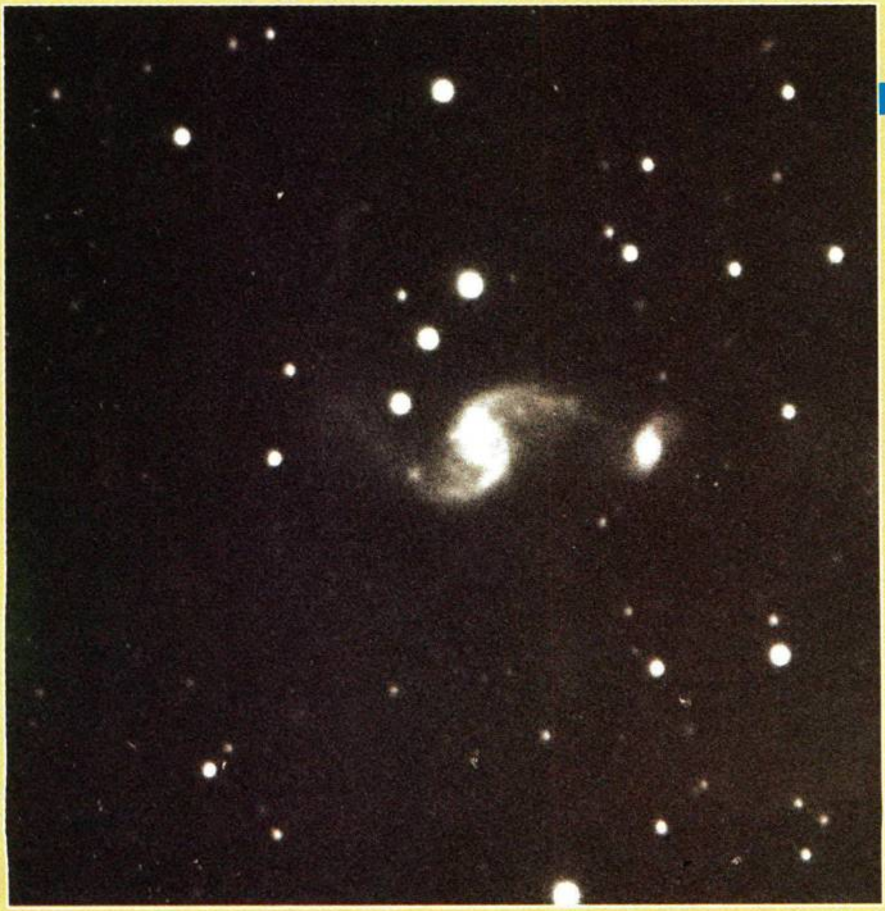
The Cocoon Nebula in Cygnus

by Ken Blankenship and Dennis Batis
(14-inch f/10 SCT, hypersensitized Fuji Super HG 400 film, 90-minute exposure)



The Hubble Repair Mission Blasts Off

by David Silverstein



Interacting Galaxies NGC 2535 and NGC 2536

by David Healy
(14-inch SCT at f/7, hypersensitized Tech Pan film, 65-minute exposure)

Orion's Birthplace of Stars

by Jason Ware
(6-inch refractor, Fuji Super HG 400 film, integration print of four 60-minute and one 12-minute exposures)

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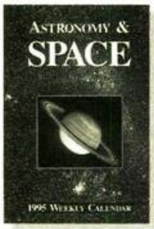

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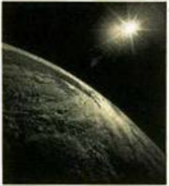

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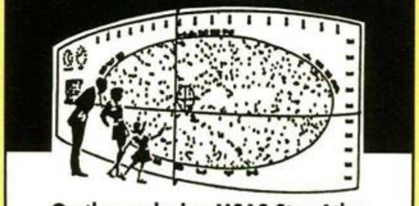

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Pictors 208 and 216 (Model 216 shown center) autoguider/cameras both feature a 336x242-pixel array thermoelectrically cooled to –5°C. Each has an electronic shutter and can also be used for autoguiding. The 208 uses an 8-bit A/D register that permits 256 shades of image brightness, while the 216 has a 16-bit A/D converter permitting 65,536 brightness levels. Both cameras use 10 micron pixels.

The Pictor 416 autoguider/camera incorporates a 768 x 512-pixel array, 16-bit A/D converter, and an electromechanical shutter, and is thermoelectrically cooled to –20°C. The Pictor 1616 (bottom) is identical to the 416, except it comes equipped with a 1536 x 1024-pixel (13.80 x 9.20mm) array. Both cameras have 9 mm pixels.

When used with Meade LX200 telescopes, Pictors 216, 416, and 1616 autofocus and automatically shoot mosaics of the sky.

Meade Instruments Corporation, 16542 Millikan Avenue, Irvine, CA 92714, (714) 756-2291, fax: (714) 756-1450. Pictor 201: $405; Pictor 208: $810; Pictor 216: $1,210; Pictor 416: $2,520; Pictor 1616: $7,035. All prices *include shipping and handling.*

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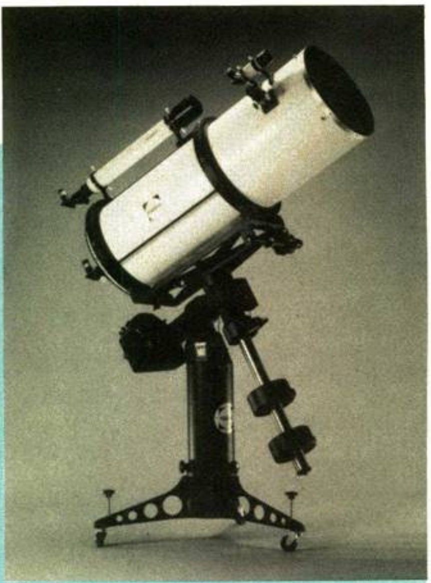
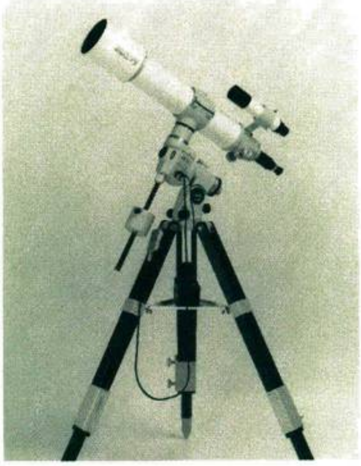


16-inch Newtonian/Cassegrain Reflector

The 16-inch Observatory Telescope manufactured by Parks can work as an f/20 Cassegrain or f/3.5 Newtonian. It features 2 1/2-inch stainless steel right ascension and declination shafts, a drive corrector with a built-in battery that provides six hours of power, and an adjustable-height pier. The mirror is made from pyrex glass and is specially coated to enhance reflectivity.

Parks Optical, 270 Easy Street, Simi Valley, CA 93065, (805) 522-6722. $22,999.



102mm Refractor from Takahashi

Takahasi introduces its first line of fluorite refractors in 10 years. At the heart of the FS-102 is a 102mm f/8 doublet objective lens that is multi-coated on all surfaces. The refractor tube assembly can be purchased separately, or as part of three package options. All option packages include a wooden tripod, 18mm ocular, and 1.25" diagonal prism. The TSS1022 package comes equipped with an EM-1S mount; the TSS1032, an EM-10 electric mount; and package TSS1042, an EM-200 all-electric mount.

Texas Nautical Repair, 3110 S. Shepherd, Houston, TX 77098, (713) 498-4756. Package TSK1021 (tube assembly only): $1,947; TSS1022: $3,894; TSS1032: $4,356; TSS1042: $5,445; 7x50 finder: $90; finder holder: $39.60; tube rings: $90.

New Binocular Series from Celestron

Celestron introduces its Nature series of binoculars, which offer fully coated optics and BK-7 prisms. The 7x35 and 7x50 models are rubber coated, while the 8x40 has a textured leatherette finish with rubber-covered objective rings. All come with a soft case and lens caps. The 7x35 has a near focus of 15 feet, eye relief of 17mm, and a 9.5° field of view, and weighs 19 ounces. The 7x50 will focus down to 19 feet, weighs 25 ounces, has an eye relief of 18mm, and gives a 6.8° field of view. The 8x40 focuses down to 15 feet, weighs 19 ounces, and has an eye relief of 13mm and a 8.2° field of view. All come with a limited lifetime warranty.

Celestron, 2835 Columbia St., Torrance, CA 90503, (310) 328-9560, fax: (310) 212-5835. Model 71171, 7x35: $130; model 71172, 7x50: $140; model 71176, 8x40: $110.

Firstscope 60

The latest altazimuth refractor from Celestron, the 60mm Firstscope 60, comes with a 5x24 finder, two eyepieces (35x and 117x), and an adjustable wooden tripod. The telescope tube is made from aluminum and has a glossy black finish. The scope comes with a limited lifetime warranty.

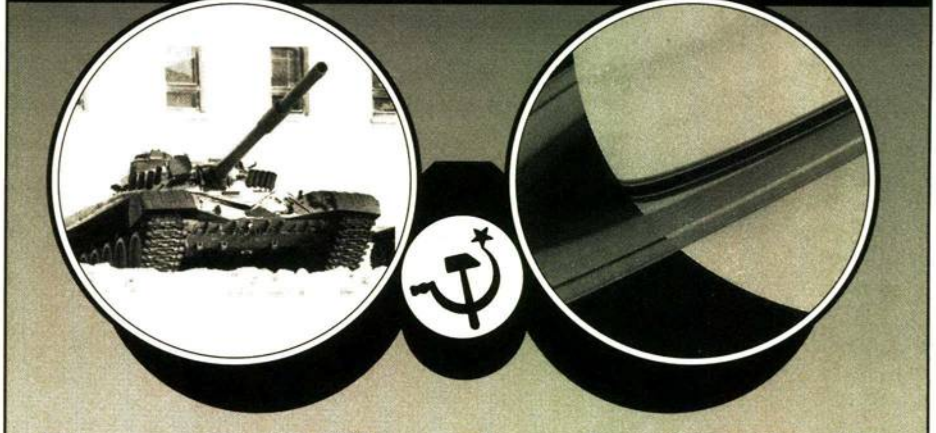
Celestron, 2835 Columbia St., Torrance, CA 90503, (310) 328-9560, fax: (310) 212-5835. $198.

Hands-on Astronomy Kit

Project STAR at the Harvard-Smithsonian Center for Astrophysics has developed a kit for astronomical lab activities. It has materials to build your own celestial sphere, 16x refracting telescope, and spectrometer. Included is an activities book that explains how to use the kit's instruments.

Learning Technologies, Inc. 59 Walden Street, Cambridge, MA 02140, (800) 537-8703. $18 plus $6 shipping and handling.

This department presents new product announcements issued by their manufacturers. Product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers should send their product announcements to the attention of John Shibley.



Nyet...Da!

Warsaw Pact Military Binoculars (EDF 7x40)

Never before available in the West, the EDF 7x40 was originally designed for East German border guards along the Berlin Wall. Roof prism small yet built for a Siberian winter, these are among the finest binoculars ever made. Absolutely dazzling optical clarity with many unusual features. Built in East Germany by Carl Zeiss-Jena; exceptional price of $499 while supplies last. *Nine other models also available, starting as low as $199.* Own a piece of history you can use!

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65 MK includes telescope with finder, 1.25" star diagonal, photoadapter, 30mm Kellner eyepiece and case. $795.00 US

We also are carrying a 100mm f/10 Rubinar telephoto/spotting scope from Russia. This is a 5-element design including a field flattener for superb optical performance. Tele-photo/spotting scope comes with dew shield, eyepiece adapter, 5 filters and case. $599.00 US. Shipping $15.00 US min.

Russian Eyepieces 18mm Bertele 80 degree field, corrects coma in wide aperture mirrors (f/4) as far off as 1 degree of the axis. $46.00 US. 30mm Kellner $42.00 US. Star Diagonals $70.00 US. Barlow lens $70.00 US. Stepper Motor Drivers $79.95 US. 600 step motors $39.00 US.

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LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

NGC 55 in Sculptor. 2 hour photo by Andrew Peters (from South Australia) using hypered 2415 film and a 20" f/5 telescope with LUMICON Coma Corrector and LUMICON 2" Easy-Guider. "The Coma Corrector is a terrific accessory," stated Mr. Peters. You may need to use a LUMICON Deep-Sky Filter to see NGC 55 visually.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90

Genesis 4" f/5 4 element fluorite	$1885
Pronto 70mm f/6.4 apochromat w/2" diagonal	$825
Pronto 70mm f/6.4 w/45° erecting prism	$725
Renaissance-SDF 4" f/5.4, brass	$2095
Gibralter mount with ash wood tripod	$495
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$79
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow - 2x	$169
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 65°	$145
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "Rich-Field!" 65°	$299
4.8mm Nagler, 82° field, 1¼" eyepiece	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, 1¼" or 2"	$219
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$159
2" Paracorr Visual Coma Corrector	$249
NEW! 15mm Panoptic 1¼", 68° field	$199
NEW! 22mm Panoptic 1¼"/2", 68°	$249
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The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount $59.50
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Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$59.00	$49.00
52, 55, 58, 62mm	$69.00	$59.00
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82mm	$89.00	N/A

Hypered 2415 film, 36 exp .. $11.95, $3/$32

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LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$165.00**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*
Astronomy, Feb. 1991

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0.96" **LUMICON DEEP-SKY Filter** threads into most 0.96" eyepieces	$59.50
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**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

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U.S. Patent 4,473,636

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U.S. Patent 4,448,500

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Pentax 6X7 **add $119;** Pentax 645 **add $139**

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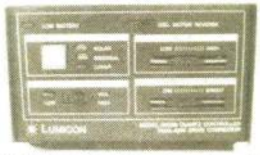
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**



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Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

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Variable dec. speed drive w/built-in 5AH battery **$299**

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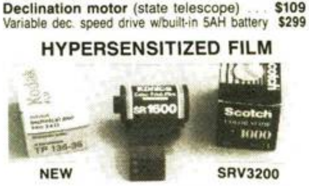

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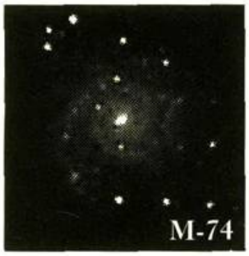
Kodak Ektar 1000 fast, fine grain	24	$12.95
Fuji HG400 fine grain color neg.	24	$14.95
Scotchrome 400, fast slide film	12	$12.95
Fujichrome RD100, fine grain slide	24	$12.95
D-19 B&W Developer	1 gal.	$6.95

CIRCLE NO. 96 ON THE READER SERVICE CARD

How to catch a really big fish.

Pisces and Cetus swim into view these crisp, autumn nights, accompanied by Aquarius. They all offer a sea of deep sky objects that are best seen with Lumicon products.



A very difficult Messier object, Pisces' M74 can be photographed with our Easy Guider. This off-axis guider allows photography at about f/6 with f/10 SCTs. Non-photographers use it as a rich-field viewer for the Double Cluster, Hyades and Pleiades, among other objects. $189.50 for Newtonians, $249 for 8" SCTs, $395 for 10-16" SCTs.*

Cetus the Whale is famous for NGC 246. This ghostly nebula is visually stunning with our OIII filter ($99.50 for 1.25" and $199.50 for 48mm*). This filter is ideal for observing the very faintest planetary and diffuse emission nebulae. Our dual axis drive corrector ($249*) is essential to precisely track and shoot long-exposure photos of this planetary nebula.

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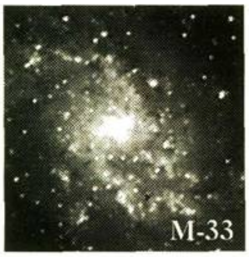

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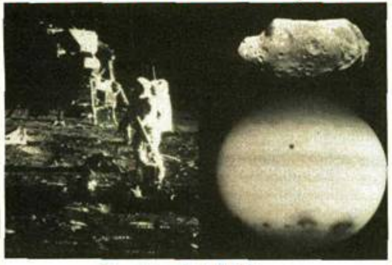

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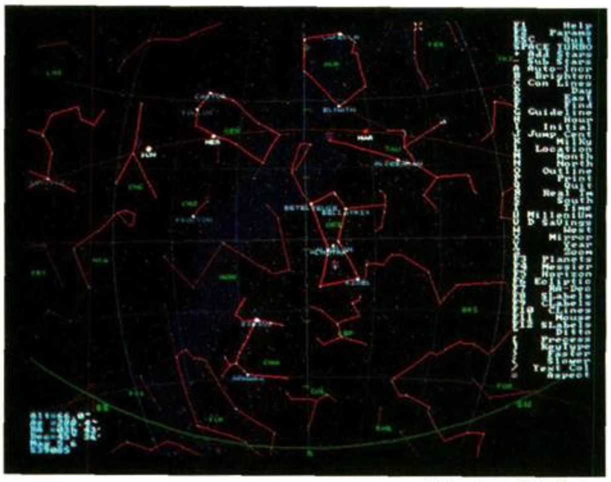
ASTROBYTES

View the Sky with Shareware

SkyGlobe (3.6)
KlassM Software, Inc., 284 142nd Avenue, Caledonia, MI 48316, (800) 968-4994. Price: $20. Minimum requirements: IBM PC-compatible computer, 640 KB of memory, and graphics display. Optional SAO star catalog database: $5. Optional GIF image sets (require Super VGA display), eight or nine images per set — inner planets, outer planets, deep-sky objects, and miscellaneous selection: $5 per set.



ASTRONOMY: Chris Becker

Shareware is a neat system. Program developers put their software on display on a bulletin board or computer service such as CompuServe, so users can try the software out. All they need is a modem and a communications program to download the software (see the "1994 Software Buyer's Guide," May 1994, for a listing of bulletin boards and services). If users like the program, they can register with the developer and pay a small fee for its use. Registration operates on an honor system; in fairness to the developers, users should pay the nominal fee if they use the program beyond a short trial period — developers deserve it. And registering a program often entitles users to a printed version of the manual, optional databases, or perhaps an extended version of the program with additional features.

One of the more popular shareware programs available through bulletin boards is *SkyGlobe*. For $20, it's a great planetarium-type program for beginners. *SkyGlobe* shows 29,000 stars down to magnitude 7.6, all the planets, 110 Messier objects, and 112 objects from the *New General Catalogue*. The program displays only one map projection (a standard azimuthal projection of the globe), but users can show a right ascension-declination grid and lines depicting the ecliptic (path of the Sun through the sky) and the local horizon. The horizon has labels at the north, south, east, and west points. Tick marks can be added to show elevation above the horizon.

Two data boxes that users can turn on and off provide information about the display. One gives the time, date, zoom factor, magnitude of the faintest star shown, number of stars at that limiting magnitude, altitude and azimuth of the screen center, and the observer's location, latitude, and longitude. The second box states the right ascension, declination, altitude, and azimuth of the cursor's position and, if the cursor is centered on an object, its name and magnitude.

Users can zoom in from an all-sky map (180° across) to a region about 5° across. A single keystroke will mirror the sky map east-west to make finder charts for use with star diagonals. Changing observer location is easy. *SkyGlobe* comes with two location tables: One lists 116 cities in the United States and the other lists 116 cities in other countries. Users can also choose from viewing sites at the North Pole, South Pole, and the equator (0° longitude).

The brightest 3,216 stars can be labeled by name or their order in brightness. Not only can users turn the star labels on and off but they can control the number of labels shown from just the brightest star names to all the star names, or levels in between. Most of *SkyGlobe*'s features have similar ability to fine-tune sky maps, controlling levels of display, colors, line type, or time interval. The software accomplishes this by chording keystrokes. For example, the F7 key turns the right ascension-declination grid on, while Alt-F7 toggles between solid and dotted grid lines. Be careful though — some key combinations spell trouble: X mirrors the display but Alt-X quits from the program.

The program can show the outline of the Milky Way in the sky (in outline,

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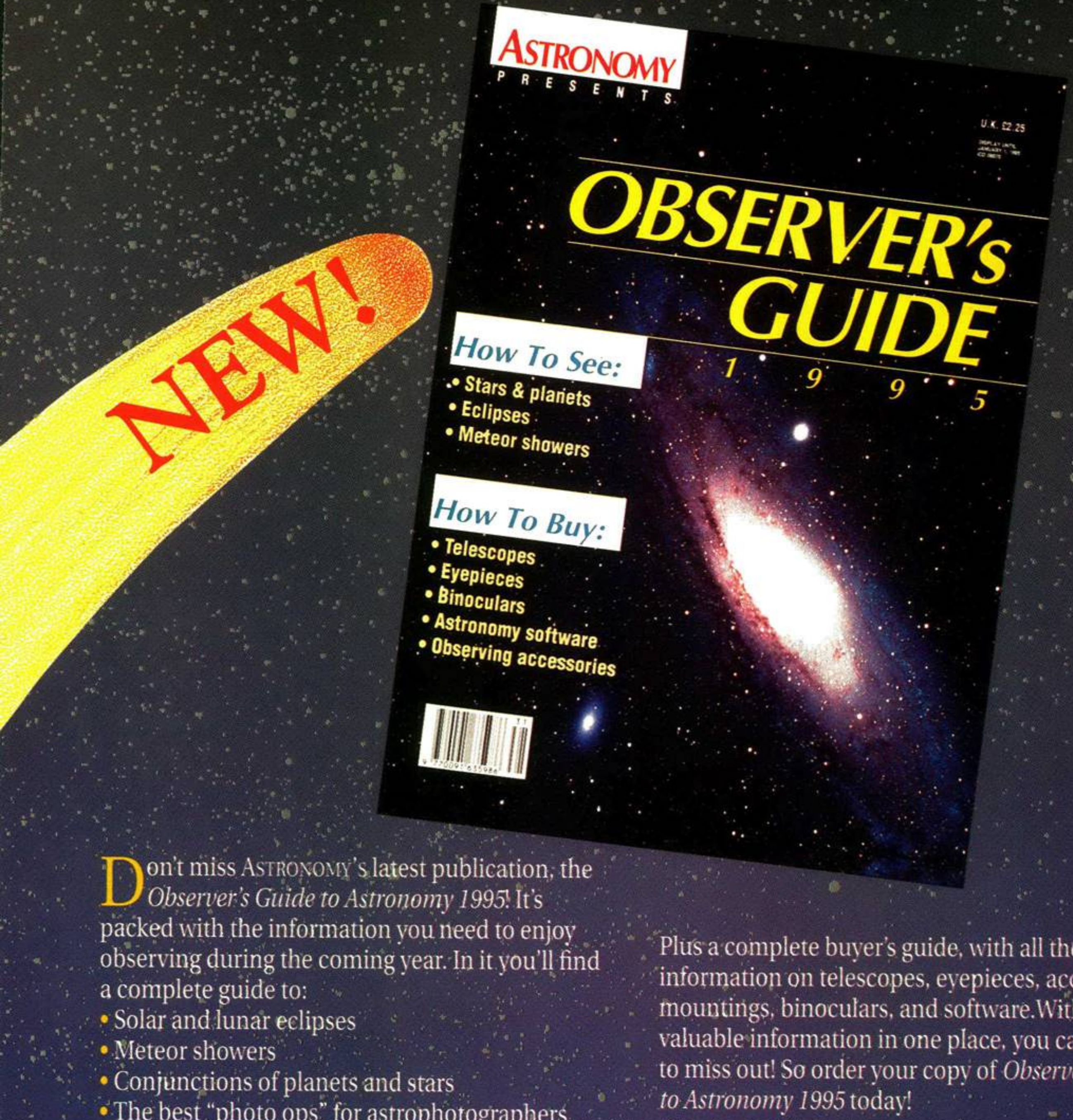

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8"	95.00	8"	85.00
10"	109.00	10"	99.00
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6"	135.00	6"	115.00
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gray, or blue). It can plot constellation boundaries and lines (all or some of the constellations). Simple key commands can step time by an hour, day, month, year, or millennium. Because the program accounts for precession, the 26,000-year wobble of Earth's rotational axis about the sky, it can display the appearance of the sky for any date in the past or future. (Caution: Planetary positions may not be accurate for dates far from the present time.)

SkyGlobe packs a lot of punch for an inexpensive program. It has a good-sized database and offers a bundle of features that permit users to customize their sky maps. Its limitations are that it doesn't plot a horizon map of the sky and the database doesn't contain very many NGC objects. *SkyGlobe* is an excellent choice for beginners wanting to explore the sky using a computer. — *Dave Bruning*

Discover Space

Brøderbund Software, P.O. Box 6125, Novato, CA 94948-6125, (415) 382-4400. Price: $59.95. Minimum requirements: IBM PC-compatible computer, 560 KB of free memory, 7 MB of hard disk space, 3.5" floppy disk drive, DOS 3.1, and VGA display. Recommended: 16 MHz 80386-based computer, mouse, and a sound card.

Part computerized encyclopedia and part planetarium-type program, *Discover Space* is a great program for beginners. The opening screen offers six different options: studying the Sun, surveying the planets, exploring 18 deep-sky objects, examining comets and asteroids, learning about space exploration, and displaying a sky map.

Each of the first five options presents a second screen with additional choices. For example, choosing the Sun brings up four new choices that let the user learn about the Sun's composition, solar eclipses, the birth and death of the Sun, and important data such as our star's diameter and mass. Options for the planets include viewing the motions of the planets and comparing their diameters, masses, rotation periods, and surface gravities. Clicking on highlighted words in text boxes provides a definition of the term, and a glossary button is often visible for accessing additional definitions.

The planetarium portion of the program provides the mythology surrounding the constellations and two views of the night sky: a celestial sphere and a skyline. The celestial sphere shows the stars, planets, and 110 deep-sky objects plotted on a globe, as if all the objects were located at the same distance from Earth. The skyline shows a horizon view of the night sky. Jumping between the two views is easy with a mouse click. Both of these sky maps provide a lot of features, such as the ability to control the number of constellations plotted and the number of stars and deep-sky objects labeled. The observer's location can be set using a list of cities, a world map, or by zip code.

The sky maps can show a right ascension-declination grid, the ecliptic (path of the Sun through the sky), and the Milky Way. The celestial sphere maps can zoom from a 180° field of view down to 10°. Exploring the sky is simple with an altitude and azimuth system of moving around the map. Users can choose to display the position of an object in right ascension and declination or in altitude and azimuth. The sky background will darken to show the sky as it appears in the country versus an urban area. The brightness of the faintest star seen can be set, but the program won't identify the magnitude level. Clicking on an object will identify it and provide its position, but it doesn't tell what kind of object it is or give its brightness.

Minor complaints include the use of only British Imperial units such as the mile. Metric units are the standard in science and it would be helpful if science programs, especially educational software, would use this system. The solar eclipse viewer shows the corona even during partial phases when it isn't visible, and the animation of Comet Halley in its orbit uses different time intervals, so it is hard to see the comet speed up and slow down in different parts of its orbit.

These complaints aside, *Discover Space* is sure to engage beginning astronomers, especially young ones. Even after they exhaust the encyclopedia parts of the program, the planetarium portion will continue providing pleasure, enabling them to learn and explore the night sky. — *Dave Bruning*

Astronomy on Internet

Readers with direct access to the Internet can subscribe to some mailing lists that provide useful information. The mailing lists are usually operated by a program called listserv. You can subscribe to a list by sending a message containing only the words SUBSCRIBE listname your-first-name your-last-name. For example, Joan Smith subscribes to the mailing list of the Students for the Exploration and Development of Space (SEDS) by sending SUBSCRIBE SEDS-L Joan Smith to listserv@tamvm1.tamu.edu. Finding mailing lists is easy with *The Internet Directory* by Eric Braun, (Fawcett Columbine, 1994, 704 pages, softcover, ISBN 0-449-90898-4, $25). ☐

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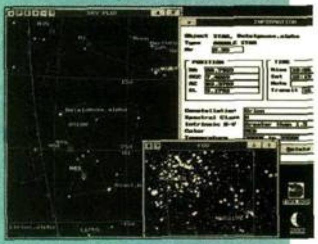

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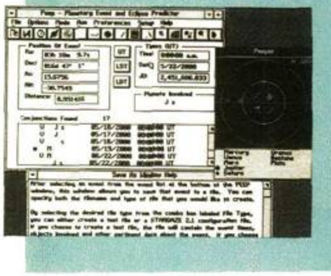

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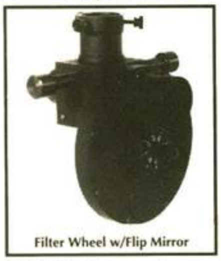
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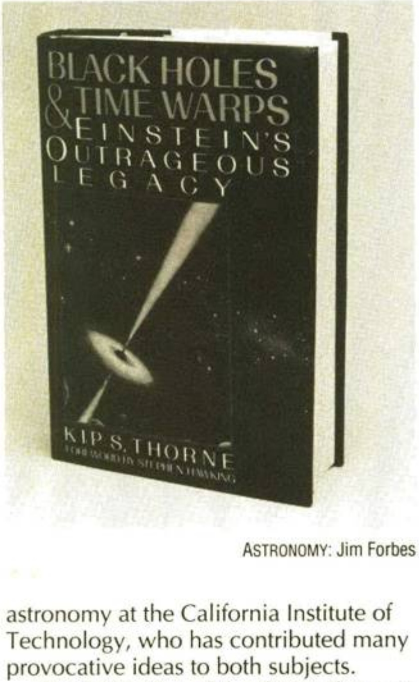
ASTRONOMY BOOKS

Space and Time

Black Holes and Time Warps

Kip. S Thorne, (W.W Norton and Co., New York), ISBN 0-393-03505-0, 619 pages, hardcover, $30.

The possibility of time travel and the mysterious nature of black holes remain two of the most intriguing ideas in modern physics. Both subjects are thoroughly covered in this hefty book by Kip Thorne, a professor of physics and astronomy at the California Institute of Technology, who has contributed many provocative ideas to both subjects.



ASTRONOMY: Jim Forbes

The inside flap of the dust jacket says that this book is a slower-paced exercise in mind stretching than *A Brief History of Time,* Stephen Hawking's highly successful book. This is not always so. *Black Holes and Time Warps* covers such subjects as stellar evolution and fundamental particle physics quickly, so readers need prior knowledge to comprehend the entire text in a reasonable time, say a month or so.

Sidebars often (perhaps too often) interrupt the text, elaborating on special topics in astronomy or physics. These diversions remind me of Thorne's style of lecturing, which I observed when I took a class of his on stellar interiors. Often he would stop his lecture on the main board and move to a side board where he presented a related topic. Perhaps the frequent use of sidebars provides a similar service; it is an attempt to widen the potential audience, a way of presenting ideas at different levels of complexity. A better treatment may have been to stay with a narrower audience and not worry about being all things to all people. But these asides are the main criticism I have of the book.

Many chapters contain a personal narrative of how ideas about black holes were developed. Thorne is very open. Besides telling when colleagues' ideas were wrong, he sheds his own intellectual clothes where appropriate. For example, Thorne, Hawking, and almost all other black hole experts ridiculed the initial suggestion that black holes could evaporate by radiation.

After years of raucous discussion at scientific meetings and testy exchanges among scientists of institutions worldwide, Thorne and others finally accepted the idea. Afterward, they explored how such radiation would have affected the history of the universe. This anecdote reveals that research is conducted as a social enterprise. Scientists mix and match arguments about ideas until they find a solution.

In the final chapter, Thorne pushes well beyond the edge of established science and considers the possibility of time travel by speculating about what happens at small scales, those much smaller than the size of a proton. The uncertainty inherent in quantum physics suggests that both space and time do a jittery dance at small sizes and short times. Thorne describes the jittering as a foam and considers what might be possible if the quantum performers of the dance could be enlarged to our size. Might it be possible to make wormholes in space? How would this effect appear to us? Might other extraterrestrial civilizations have already done so?

Black Holes and Time Warps is a mental journey to the edge of today's physics, one that requires a great deal of concentration. It records the trials and successes of a scientist who is establishing new doctrines in the way we perceive the universe. But in the end, readers may also understand what engages so many other physicists in the workings of the cosmos. — *John J. Dvorak*

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Pierre Marchand, (Scholastic, Inc, 1994), ISBN 0-590-47615-7, 48 pages, spiral bound hardcover, $19.95.

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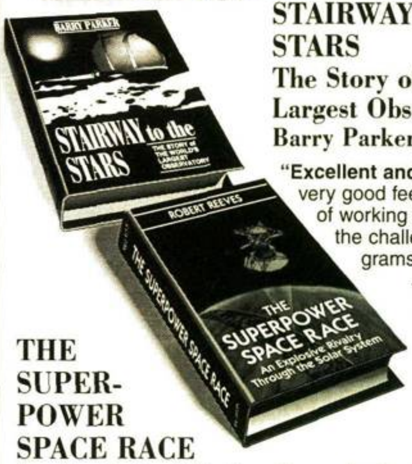
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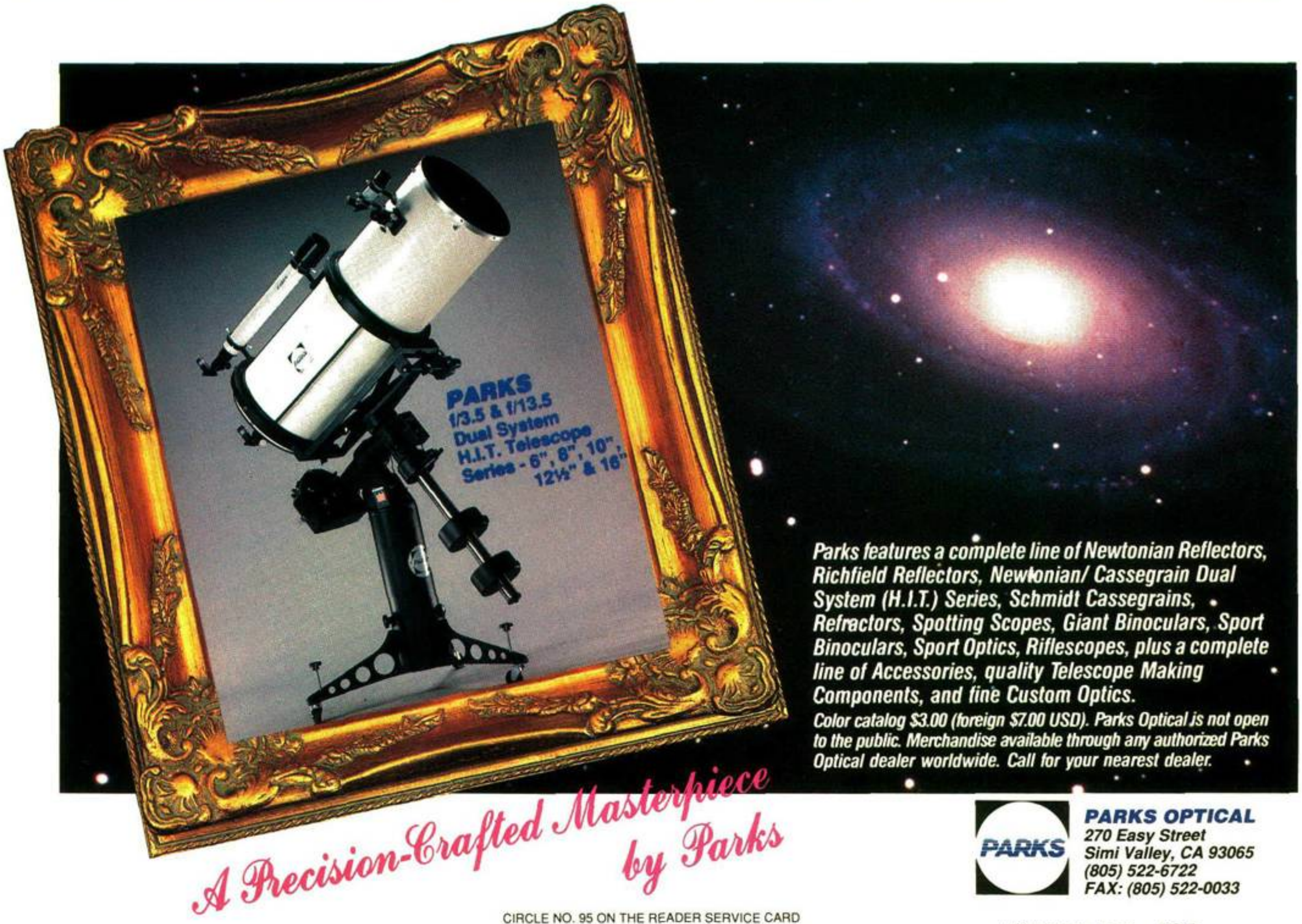

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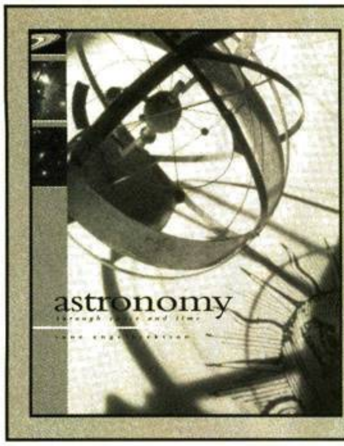

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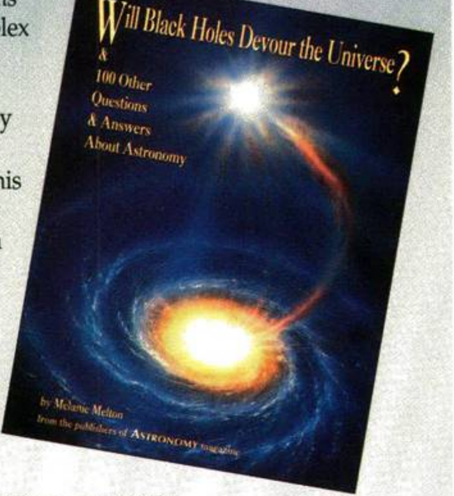
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few years that will introduce children eight years and older to natural history, visual arts, performing arts, and science and technology. Throughout this book are colorful illustrations, pop-ups, cutouts, and transparent pages that introduce young readers to all aspects of astronomy. The book begins with an explanation of constellations and the zodiac.

A built-in planisphere and Little Dipper clock conveys how the sky changes with time of day and season. Marchand then examines the Moon's nature and motion and provides a history of its exploration by humans and machines before moving out to the Sun, planets, and Milky Way. Star maps that use a pseudo-3D effect (special glasses provided) give an impression of stellar distances. A simply written and lavishly illustrated book, *Exploring Space* is a worthy addition to any young astronomer's bookshelf.

Home Is Where the Wind Blows

Fred Hoyle, (University Science Books, 1994), ISBN 0-935702-27-X, 446 pages, hardcover, $32.50.

Never one to shun the limelight, astronomer Sir Fred Hoyle speaks his mind. As a strong advocate of the steady state theory of the universe, Hoyle sarcastically coined the phrase "Big Bang" to describe a rival view of the universe's creation. He also proposes that the Sun's retinue of planets formed when a companion of our star exploded. In the late 1970s, he attributed sudden pandemics on Earth to microbiological contamination from comets.

Quirks aside, Hoyle has made significant contributions to science with his study of the synthesis of elements in exploding stars and his work on radar during World War II. He is also a prolific writer of science fiction and fact (as he sees it). This autobiography is a frank and entertaining look at his life, from its beginnings in a blue collar neighborhood in war-torn England, through Hoyle's brilliant if controversial career as scientist and author.

Moon Shot

Alan Shepard and Donald Slayton, (Turner Publishing, Inc. 1994), ISBN 1-878685-54-6, 383 pages, hardcover, $21.95.

As two of the seven Mercury astronauts, Alan Shepard and Donald Slayton had front-row seats to America's push to the Moon from the very beginning. In *Moon Shot*, both share insights and unique stories (many of them very entertaining) about America's space effort,

(continued on page 112)

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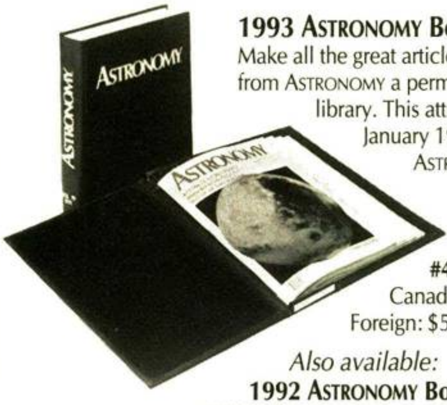

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from Mercury through the last flight of Apollo in 1975. Though he never walked on the Moon, it was Slayton who commanded Apollo's final mission. Not long after his selection to the astronaut corps in 1959, Slayton was diagnosed as having an irregular heartbeat. Flight surgeons grounded him from spaceflight until the 1975 Apollo-Soyuz test flight. As head of the astronaut office during the 1960s and 70s, Slayton selected who would fly in space, and thus who would ultimately walk on the Moon. He had a great deal of power but not the power to fly.

Shepard did fly (for 15 minutes in a Mercury suborbital flight) before an inner ear problem grounded him also. Through unconventional surgery, Shepard's problem was cured in time for him to command the Apollo 14 mission to the Moon. This book was made into a TV movie (available on video cassette) for the 25th anniversary of Apollo 11. Every self-respecting space buff should own both.

The Making of a Soviet Scientist

Roald Z. Sagdeev, (John Wiley and Sons, 1994), ISBN 0471-02031-1, 339 pages, hardcover, $24.95.

As director of the Soviet Union's Space Research Institute, Roald Sagdeev helped plan and carry out Soviet planetary exploration in the 1970s. He also ran the Soviet side of the Apollo-Soyuz test project. With wry Russian humor, Sagdeev offers an insider's account of the struggle to do honest science within a community of design bureau tsars and military-industrial barons. We read of bitter political rivalry between two design bureaus that cost the Soviets a chance to land a human on the Moon. The outcome of that struggle produced the Energia rocket, one more powerful than America's Saturn V, and the Soviet space shuttle, which made only one unmanned flight around the Earth. The loser's Moon rocket program had its remaining boosters cut up to make tool sheds.

The narrative covers a wide spectrum, including the USSR's thermonuclear program and Russia's answer to President Reagan's "Star Wars" program. The author also examines Gorbachev and suggests why his policy of perestroika doomed the USSR. At the close of his book, Sagdeev laments today's "unmaking of the Soviet scientist" and the disarray among the intellectual elite. What's ahead for space science in Russia? As Sagdeev is prone to say, "Only God knows." ☐

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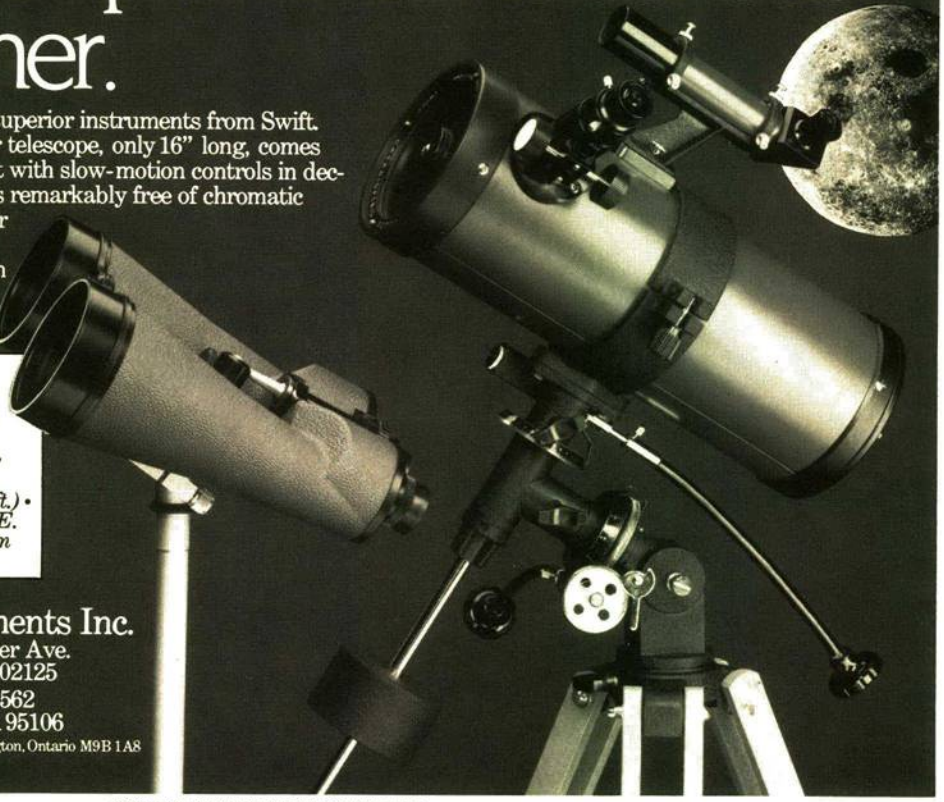

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MEETINGS & EVENTS

October 4-9
11th Annual Okie-Tex Star Party, Lake Murray State Park, Oklahoma. Sponsored by Oklahoma City Astronomy Club. Contact Beryl Cadle, 6616 N.W. 20th Street, Bethany, OK 73008.

October 7-9
Stella-Della-Valley VIII, Camp Onas, Ottsville, Pennsylvania. Sponsored by the Bucks-Mont Astronomical Association. Contact Ed Melnick, 1443 Devon Road, Warminster, PA 18974, (215) 443-7929.

October 14-16
10th Annual Midwest Space Development Conference, Harley Hotel West, Cleveland, Ohio. Contact MSDC, 524 West 6th Street, Lake Side, OH 43440-1717.

October 21-24
Antique Telescope Society's Third Annual Convention, University of Santa Clara, Santa Clara, California. Sponsored by the Antique Telescope Society. Contact Walter H. Breyer, 30 Green Valley Road, Wallingford, PA 19086, (215) 566-2227.

October 26-29
30th Annual Conference of the Great Lakes Planetarium Association, Benedum Natural Science Theater, Wheeling, West Virginia. Sponsored by the Great Lakes Planetarium Association and the Benedum Natural Science Theater. Contact Steve Mitch, Benedum Natural Science Theater, GLPA Conference, Oglebay Resort and Conference Center, Wheeling, WV 26003, (304) 243-4034.

November 3-6
12th Annual Deep South Regional Stargaze, Percy Quin State Park, McComb, Mississippi. Sponsored by The Pontchartrain Astronomy Society, Inc.. Contact Barry Simon, 820 Emerald Street, New Orleans, LA 70124, (504) 283-7562.

November 3-6
Astro Scopers' Starfest, Chiefland, Florida. Sponsored by the Astro Scopers. Contact Joanne Klein, 8350 81st Street N., Seminole, FL 34647, (813) 397-4235.

November 4-6
Regional Eclipse Convention VII, Montevideo, Uruguay. Sponsored by the Liga Ibero-American Astronomy club. Contact Ruben E. Garcia, P.O. Box 23.007, 12.800, Montevideo, Uruguay, e-mail (Internet) astronom@fisica.edu.uy, or fax 598-2-409973.

November 11-12
Fall Spectacular, Lemon Lake County Park, Crown Point, Indiana. Sponsored by the Calumet Astronomical Society. Contact Stephen J. Miller, Calumet Astronomical Society, (219) 845-9174.

November 12
5th Annual Optics Workshop, Bellingham, Washington. Sponsored by the Whatcom Association of Celestial Observers. Contact Kreig McBride, 402 E. Horton Road, Bellingham, WA 98226, (206) 671-1665.

December 1-3
3rd Annual Star Party, Lake Kissimmee State Park, 15 miles east of Lake Wales, Florida. Sponsored by the Florida Department of Environmental Protection. Contact George Aycrigg, 14248 Camp Mack Road, Lake Wales, FL 33853, (813) 696-3472.

December 3
4th Annual Star-Be-Que, near Heathcote, Victoria, Australia. Sponsored by the Astronomical Society of Victoria. Contact Perry Vlahos, 9A Hall Street, Cheltenham, Melbourne, Victoria 3192, Australia, 03-583-5930.

February 27 to March 5
1995 Winter Star Party, Girl Scout Camp Wessumkee, Florida Keys, Florida. Sponsored by the Southern Cross Astronomical Society, Inc. Contact Bob or Sharon Grant, 5401 SW 110 Avenue, Miami, FL 33165, (305) 595-8778.

March 13-17
26th Annul Lunar and Planetary Science Conference, NASA Johnson Space Center, Houston, Texas. Co-sponsored by the Lunar and Planetary Institute and the NASA Johnson Space Center. Contact LeBecca Simmons, Conference Administrator, LPI Publications and Program Services Department, 3600 Bay Area Boulevard, Houson, TX 77058-1113, (713) 486-2158. □

Clubs, please submit announcements at least four months before the date of the event to Tracy Staedter, Editorial Assistant, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Readers, when you write to organizations listed in "Meetings and Events," include a self-addressed, legal-sized envelope with your request for information.

Reader's Exchange

WANTED. Mirana, Miranda Laborec, or Mirax Laborec camera. Contact Dan Schechter, 240 Belmout Avenue, Long Beach, CA 90803, (310) 433-9745.

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FOR SALE. Lumicon Easy Guider for C8, C5, Dynamax 8/6/4, or Meade 2080 and 2040. Guides at about f/10 and good for photography at about f/5. Good condition; $75 postage paid. Contact Dick Mischke, (210) 349-7522.

FOR FREE. Astronomy software catalog containing over 500 of some of the latest astronomy and space science programs and databases for IBM and compatibles. Contact Joe Dumanov, 181 Springbrook Trail, Sparta, NJ 07871, (201) 729-9508.

FOR SALE. Meade 2120 10" SCT in perfect condition with excellent optics. Includes JMI moto-dec and moto-focus and Lumicon Sky Vector 1. Asking $1,200 or best offer. Contact Norman Smith, PSC 1, Box 1013, APO AA 34001, or call 011-507-84-4800.

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ANNOUNCEMENT. The Ancient City Astronomy Club in St. Augustine, Florida, meets at 8 p.m. every first Friday of the month at the First United Methodist Church. Contact the ACAC, P.O. Box 546, St. Augustine, FL 32085-0546, (904) 797-5704 or (904) 471-3054.

FOR SALE. Celestron Classic 8 in perfect condition, includes wedge, tripod, starbright coatings, adapter, drive corrector, Konica 35mm SLR, and back issues of ASTRONOMY (April 1976-December 1984); entire package $800. Contact Robert Price, (212) 447-0356.

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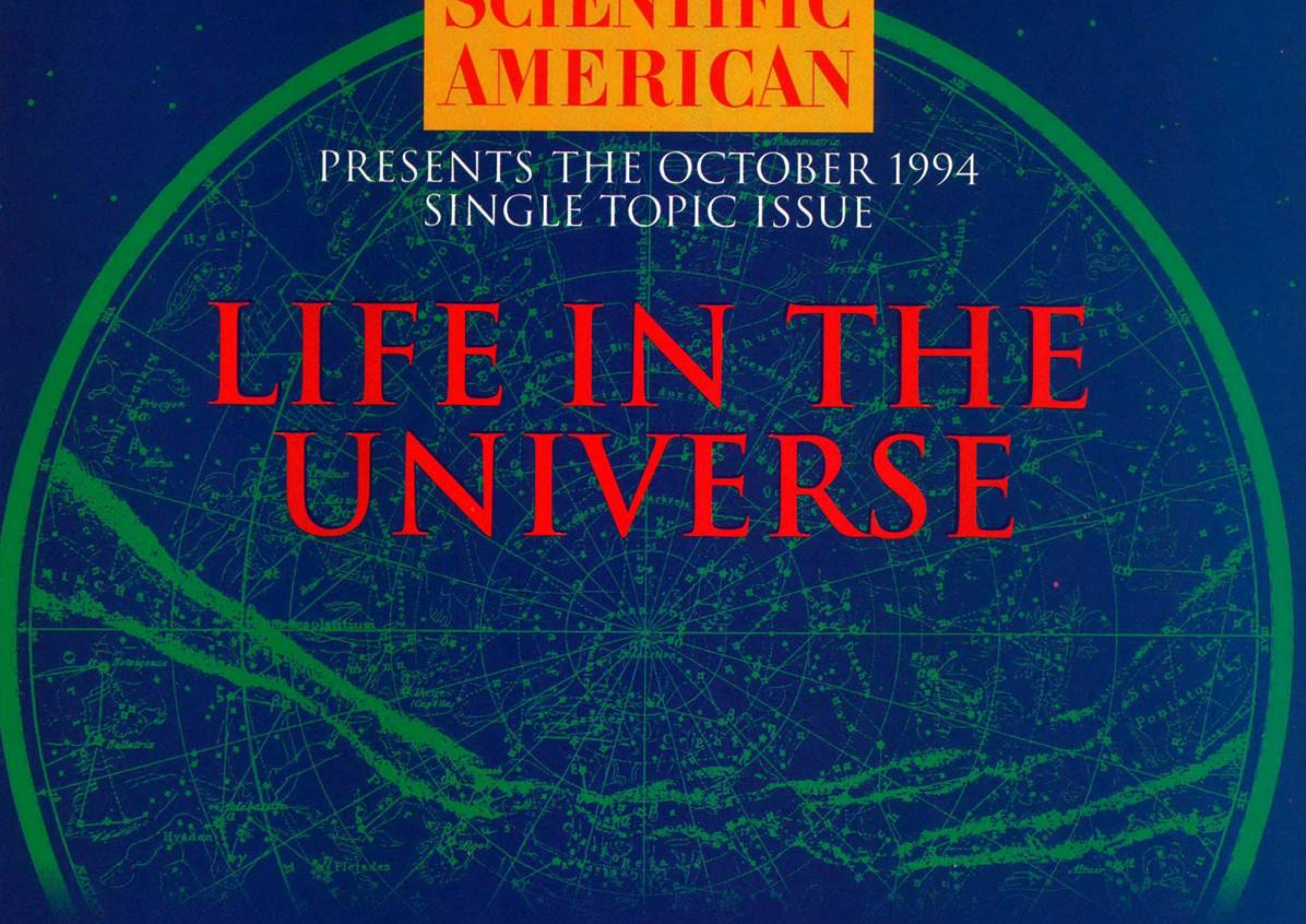
FOR SALE. *Old and New Astronomy* by Richard Proctor, 1892, 814 pp. Proctor's Magnus Opus; $150. Contact Chuck Gulker, 4865 Sarasota Ct., Hilliard, OH 43026, (614) 876-8484 after 5 p.m. EST.

(continued on page 120)



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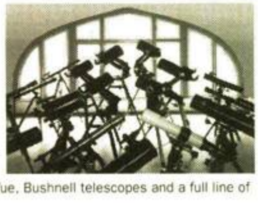

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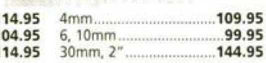

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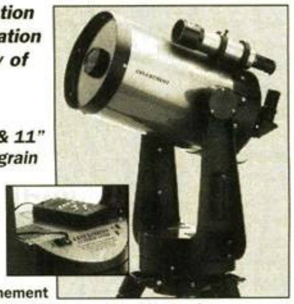

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READINGS & CREDITS

Telescopes That Fly (page 46)

Infinite Vistas edited by James Cornell and John Carr, (Scribners, 1985). This overview of observing through the electromagnetic spectrum contains a chapter that explains why it is advantageous to observe in the infrared, how astronomers view infrared sources, and what sources are best seen.

"An Infrared View of Our Universe" by Ian Gatley, ASTRONOMY, April 1994. Shows stunning infrared views of familiar emission nebulae and galaxies.

Tycho and Clavius (page 64)

Atlas of the Moon by Antonín Rükl, edited by T. W. Rackham (Aventinum and Kalmbach, 1990). Contains detailed maps perfect for most lunar observers.

The Moon: An Observing Guide for Small Telescopes by Michael T. Kitt (Kalmbach, 1992). An thorough guide to the main lunar features visible in a small telescope.

T is for Telescope (page 70)

Star Ware, by Philip S. Harrington, (John Wiley & Sons, 1994). A concise guide to purchasing telescopes and accessories.

Observer's Guide, 1995 (Kalmbach Publishing, 1994). ASTRONOMY's most recent guide to observing. Includes tables with specs on virtually every telescope, eyepiece, and binocular sold.

Eclipse (page 82)

Chasing the Shadow: An Observer's Guide to Eclipses by Joel K. Harris and Richard L. Talcott (Kalmbach, 1994). All a chaser needs to know about observing and planning a trip to view an eclipse.

Total Solar Eclipse of 3 November 1994 by Fred Espenak and Jay Anderson (NASA Reference Publication 1318, 1993). Details for the November eclipse including local weather prospects along the path.

Jupiter's Smash Hit (page 34)

The Planet Jupiter, by Bertrand M. Peek, (Faber, 1981). The classic observer's guide to Jovian phenomena.

Internet users can access the World Wide Web to get images at many sites. One collection is at http://newproducts.jpl.nasa.gov/sl9/sl9.html.

Cover: Edwin Faughn; **p. 4, top left:** NASA/JPL; **bottom right:** Andreas Gada; **p. 5:** Jean Dragesco; **p. 6:** Chris Becker; **p. 16:** K. Edwards and M. Vito; **p. 18:** Don Walton; **p. 20, top:** William Baum (Univ. of Washington) and the HST/WFPC team/NASA; **bottom:** The White House; **p. 22, top right:** E. Hu and S. Ridgway, Univ. of Hawaii; **bottom:** ESO; **p. 24:** Werner W. Zeilinger, Insitut für Astronomie der Universität Wien; **p. 26, top:** CTIO/ESO; **bottom:** Dave Bruning; **p. 30, top:** Barbel Korlbalski, Australia Telescope National Facility/CSIRO; **pp. 34-35:** Palomar Observatory; **p. 35:** STScI; **pp. 36-37, bottom left:** NASA/JPL (Galileo), NASA/Infrared Telescope Facility; **bottom center:** Apache Point Observatory; **bottom right:** Peter McGregor and Mark Allen at Mount Stromlo and Siding Spring Observatory; **p. 37:** François Colas, Jean Lecacheux, and Pierre Laques at Pic du Midi Observatory; **pp. 38-39:** STScI; **p. 39:** ESO/La Silla; **pp. 40-41:** Cyril Cavadore, Patrick Martinez, and Mathieu Sénégas, 12-inch f/6 reflector, Alpha 500 CCD camera, composite of twelve 5-sec. exp.; **pp. 46-53:** NASA; **p. 47, top and p. 49, bottom right:** courtesy of Al Harper; **p. 50:** Thomas L. Hunt; **p. 56, top:** H.C. Ng; **p. 57, middle:** Jacques Guertin; **p. 60, top left:** Paul Roques; **bottom left:** Kim Zussman; **top and bottom right:** Harvey Freed; **p. 64:** Jean Dragesco, 8-inch f/10 SCT, 1-sec. exp.; **p. 65:** Jean Dragesco, 14-inch SCT at f/40, Tech Pan film, 2-sec. exp.; **p. 66, top:** Lick Observatory; **bottom:** C. Arsidi, 12-inch Cassegrain at f/48, Tech Pan film, 1-sec. exp.; **p. 67:** L. Loechel; **pp. 70-77:** Tom Peters; **p. 78:** NASA; **p. 79-81:** Darla Evans; **pp. 82-83:** Andreas Gada, 6-inch f/6 Newtonian, Kodachrome 64 film, 1/30-sec. exp. on July 11, 1991; **p. 84:** Lee Vande Visse; **p. 85:** Hal Jandorf, 1280mm focal length f/14 lens, Fujichrome 100 film, 1/250-sec. exp. on July 11, 1991; **p. 87, top:** Adrian Catterall, 12-inch SCT at f/20, ST-6 CCD camera, taken on July 18, 1994; **bottom:** Jose Olivarez, 10-inch f/7 reflector at 195x on July 18, 1994; **p. 88, top left:** Jeff Copland, 28mm lens, 400 ISO film, 100-sec. exp. on April 16, 1994, from Belvidere, Illinois; **left center:** Bob Yen, 8-inch f/1.5 Schmidt camera, hypersensitized Tech Pan film, 4-minute exp. on April 4, 1994; **bottom left:** Gerald Rhemann, 6.7-inch Schmidt camera, hypersensitized Tech Pan film, 7-minute exp. on June 8, 1994; **right:** Peter Ledlie, 4-inch f/8 refractor, Fujicolor 100 ISO film, 1-sec. exp. on April 11, 1994; **p. 89:** Ken Blankenship and Dennis Batis, 14-inch f/10 SCT, hypersensitized Fuji Super HG 400 film, 90-minute exp.; **p. 90, top right:** David Silverstein, 500mm lens at f/5.6, Fuji Super HG 400 film, 1/250-sec. exp. on December 2, 1993; **right center:** David Silverstein, 24mm lens at f/22, Fuji Reala 100 film, 30-sec. exp. on December 2, 1993; **bottom right:** David Healy, 14-inch SCT at f/7, hypersensitized Tech Pan film, 65-minute exp.; **p. 91:** Jason Ware, 6-inch refractor, Fuji Super HG 400 film, integration print of four 60-minute and one 12-minute exp.

Reader's Exchange

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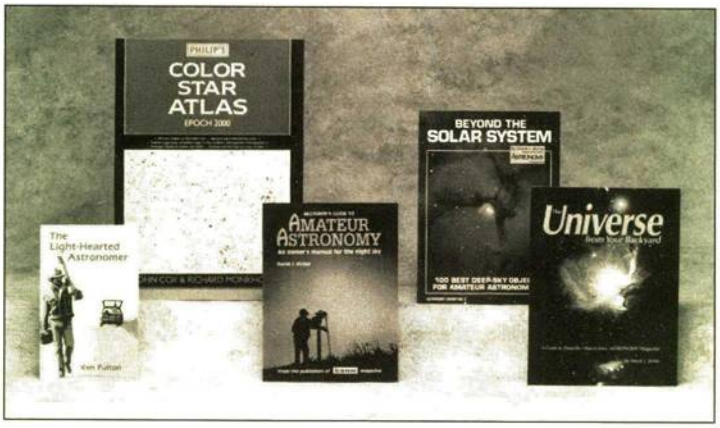

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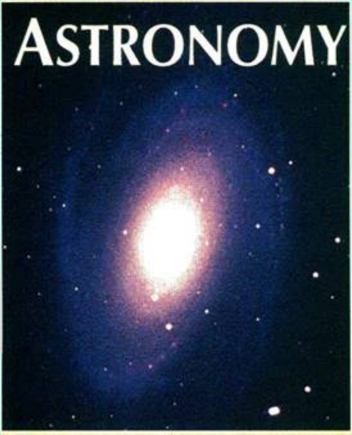

Tony and Daphne Hallas

SOMETHING OUT OF NOTHING Everyone knows mighty oaks grow from tiny acorns. But can astronomers figure out how mighty galaxies grew from tiny ripples in space-time?

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AVAILABLE ON YOUR NEWSSTAND NOVEMBER 8

ASTRONOMY

Adorama	118, 119
Andromeda Software Inc	98
Analytical Scientific	13
ARC Science Simulations	19
API Company	92
Arkatents USA	92
Astronomical Innovations	93
Astronomics	86
Astronomy Shoppe	116
AstroSystems, Inc.	94
Audobon Gallery	13
Ball Photo Supply	13, 116
Berger Brothers	116
Bethany Science	94
Dr. T. Biech	93
Bill Weaver Sporting Goods Inc	13
Blue Sky Pages	116, 117
Bob Horrell Custom Woodworking	94
Bruce Johnston Computing	95
CC Sales/Camera Corner	13
Cambridge University Press	28, 29
Camera Bug	12
Camera Shop In Bryn Mawr	13
Camera Wholesalers	12
CEB Metasystems	105
Celestron International	17, 32, 124
Central Camera Co	92
Ceravolo Optical Systems	86
Claremont Camera & Video	12
Colonial Photo & Hobby	12
Compuscope	14
Computer Business Services	104
Coulter Optical Inc	96
Cutler Camera	13
Dallas Remote System	94
Dew Remover System	94
Dover Photo Supply	12
Eagle Optics	13, 117
Eagleton's	13
Earth Home	13
Edmund Scientific Company	31
Efstonscience, Inc	13, 117
Elektra-Instruments	94
Energy Controls Inc	95
FC Meichsner Company	16
Focus Camera	110, 111
Fujinon	25
Gibeon Designs	92, 94
Giftsmith Inc	13
Anthony Grandio	18
Robert A. Haag - Meteorites	93
Ed Hamilton, Bookseller	94
Harrison	117
Infosearch	93
International Business Resources	18, 106
International dark Sky Association	112
Jackson Camera & Video	13
Jim's Photo Shack Inc	12
Johnson's Camera	13
Jim Johnson	94
KC Woodsmith	92
Kalmbach Publishing Co	103,106, 108, 112, 121
Khan Scope Center	117
Killgore Southwest	95
Land Sea & Sky Unlimited	13
Let's Talk Travel	95
Los Angeles Optical Co	102
Lumicon	100, 101
Main Sequence	95
Makewood Products	93
Marketplace, The	92, 93, 94, 95
Meade Dealer Pages	12, 13
Meade Instruments	2, 3, 7, 8, 9, 10, 11, 12, 13
Meadows Camera Shops	12
Mike's Camera Inc	12
Milfax	93
Milford Camera Shop Inc	12
Mountain Press Publishing	113
Mountain Skies Astronomical Society	95
Mr. Telescope	12
Murnaghan	106
Nature Company	12
Naturium	13
New England Meteoritical	102
New Mexico Astronomical	95, 116
Newport Glass Works	95
Nikon, Inc	33
Northstar	94
Novagraphics	92
Christian Nuesch	92
Nurnberg Scientific	116
Oceanside Photo & Telescope	12, 116
Orion Telescope Center	68, 69
Pegasus Classifieds	92
Palomar Optical Supply	92
Parks Optical	107
Perceptor	13
Pete's Photo World	13
Phils Camera	12
Photo Supply Inc	13
Planetary Arts & Sciences	102
Plenum Publishing Corp	107
Pocono Mountain Optics	109, 117
Precision Optics	27
Rainbow Symphony, Inc	95
Reader's Exchange	33, 114, 120
Redlich Binocular & Optical	13
Rex's Astrostuff	92
Riders Hobby Shops	12
Ritz Camera Superstores	13
Rivers Camera Shop	12, 116
RX Designs	86
Sandy's Select	93
Santa Barbara Instrument Group	21
Sarasota Camera Exchange Inc	12, 116
Science & Art Products	94
Science Connection, Inc	95
Scientific American	115
Sedona Telescope Center	12
Shutan Camera & Video	107
Software Systems Company	105
Springer-Verlag New York, Inc	15
Star Gazer Instruments	117
Star Hill Inn	104
Stargazer Steve	99
The Starry Messenger	95
The Starry Messenger Press	92
Starsplitter Telescopes	95
Stellar Vision	12, 116
Strata	12
Sunny Dial	93
Sunset Cliffs Merchandise	99
Swift Instruments, Inc	113
Tech 2000	94
Technical Innovations	98
Tele Vue Optics, Inc	123
Telstar	99
Thousand Oaks Optical	104
Tracy-Adams Photo Supplies Inc	13
Tuthill, Roger W. Inc	12, 25, 98
Travel Star	93
Tubesing T's	93
Urania	93
Vanguard Electronic Labs	94
What A World	12
What In The World	12
Wholesale Optics (Pauli's)	97
Wm. C. Brown Publishers	108
Wolf 359	25
Wonder Works	117
Yost & David	92
Zeiss Group, Astronomical Inst.	23
Zephyr Services	31

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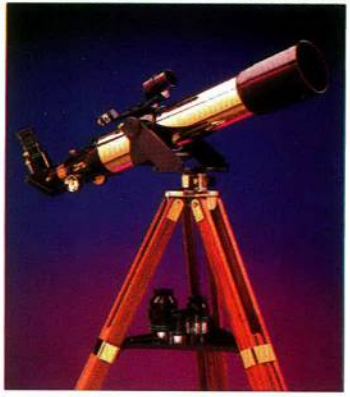

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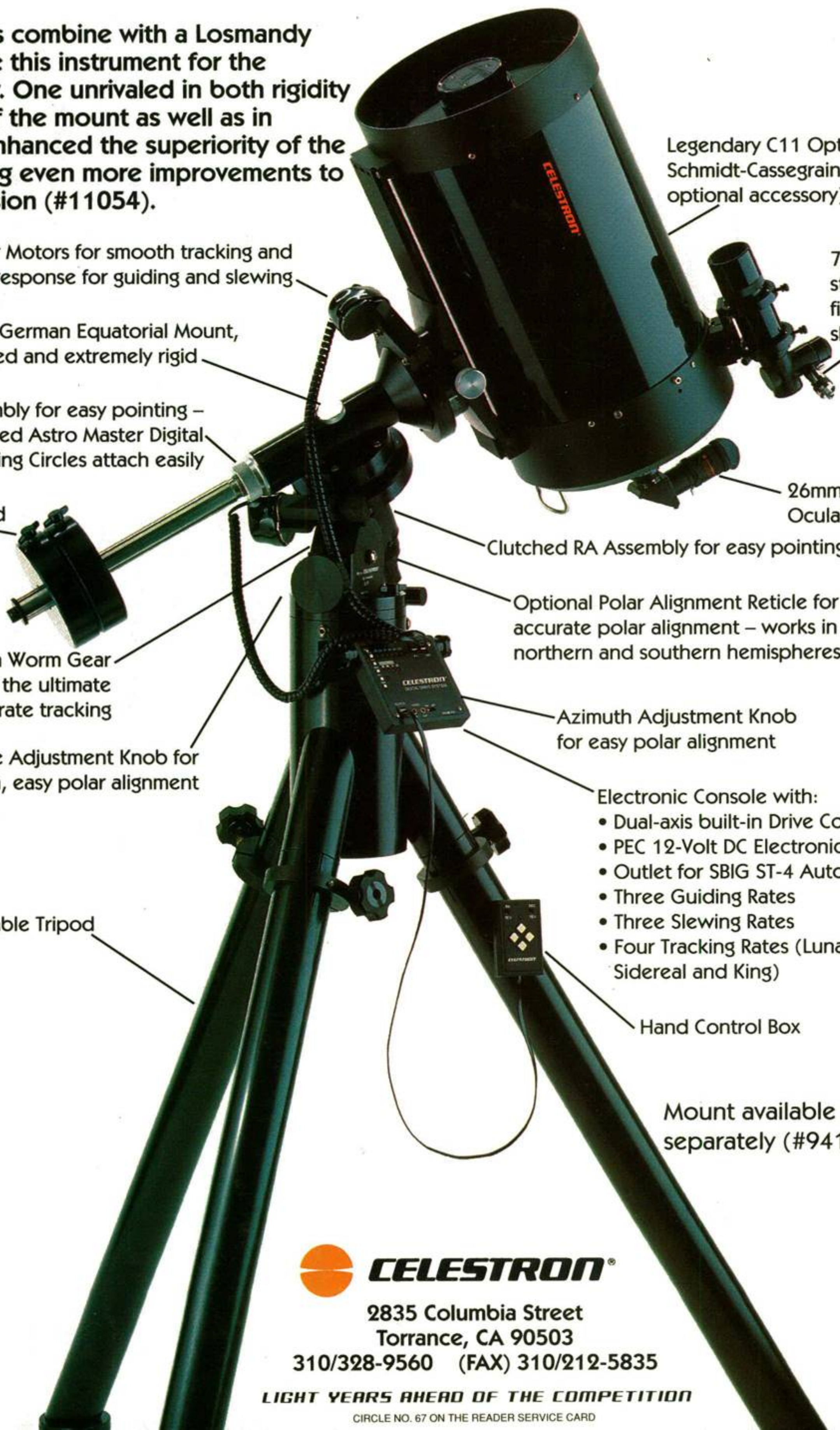

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